EXHIBIT A

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Conklin et al.

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(45) **Date of Patent: Dec. 30, 2014**

(54) **POWER MANAGEMENT FOR AUDIENCE MEASUREMENT METERS**

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H04H 60/32 (2008.01)

(52) **U.S. Cl.**
CPC ***H04H 60/32*** (2013.01)
USPC **725/14**; 725/12; 725/16; 725/25; 725/57; 725/95

(58) **Field of Classification Search**
USPC 725/14, 16, 25, 95, 12, 57
See application file for complete search history.

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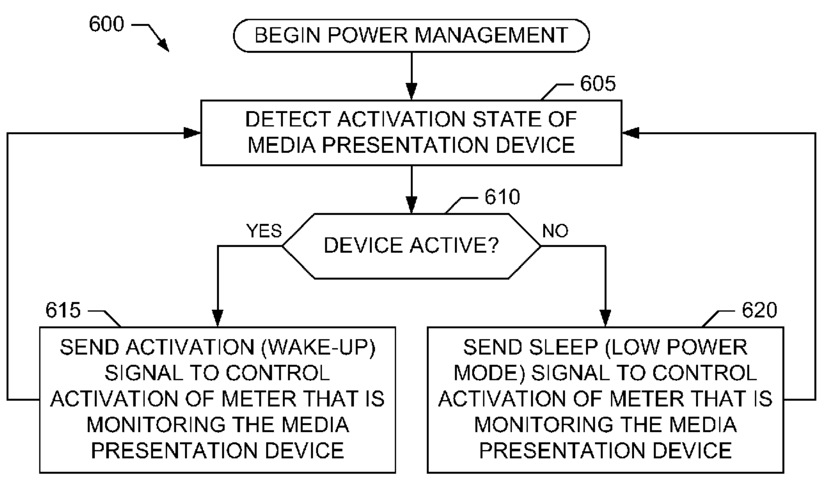
(57) **ABSTRACT**

Power management methods, apparatus and articles of manufacture for audience measurement meters are disclosed. An example method disclosed herein comprises determining an activation state of a media presentation device, and controlling activation of an audience measurement meter based on the activation state of the media presentation device, the audience measurement meter to monitor the media presentation device when the activation state is an active state. Another example method disclosed herein comprises obtaining presentation device state data representing an activation state of a media presentation device to be monitored by an audience measurement meter, the presentation device state data including time information, and determining whether to fault audience measurement data reported by the audience measurement meter based on the presentation device state data and outage information determined from the audience measurement data.

21 Claims, 8 Drawing Sheets



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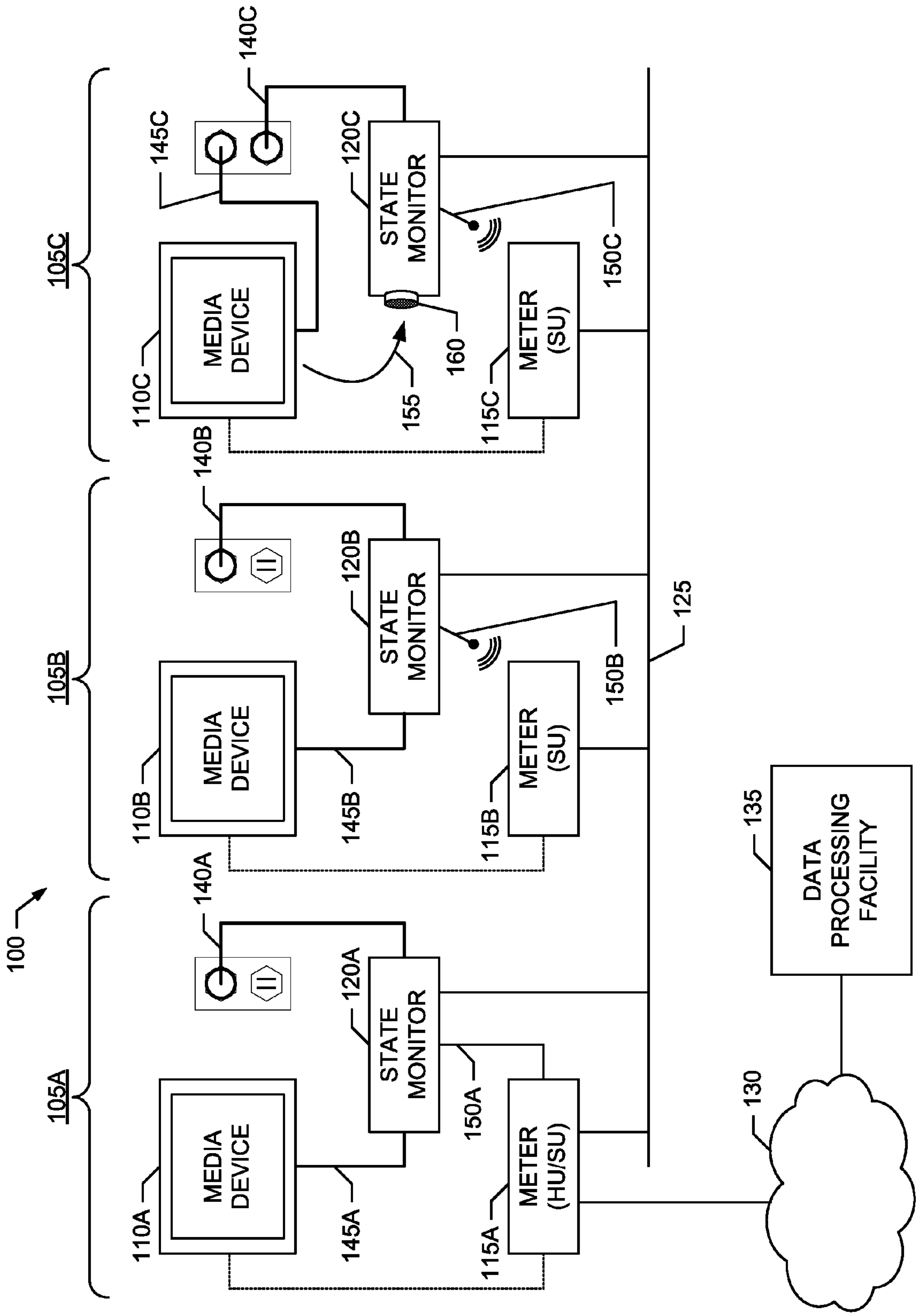

100
105A
105B
105C
MEDIA DEVICE
110A
110B
110C
145A
145B
145C
STATE MONITOR
120A
120B
120C
140A
140B
140C
METER (HU/SU)
METER (SU)
115A
115B
115C
150A
150B
150C
155
160
125
130
135
DATA PROCESSING FACILITY

FIG. 1

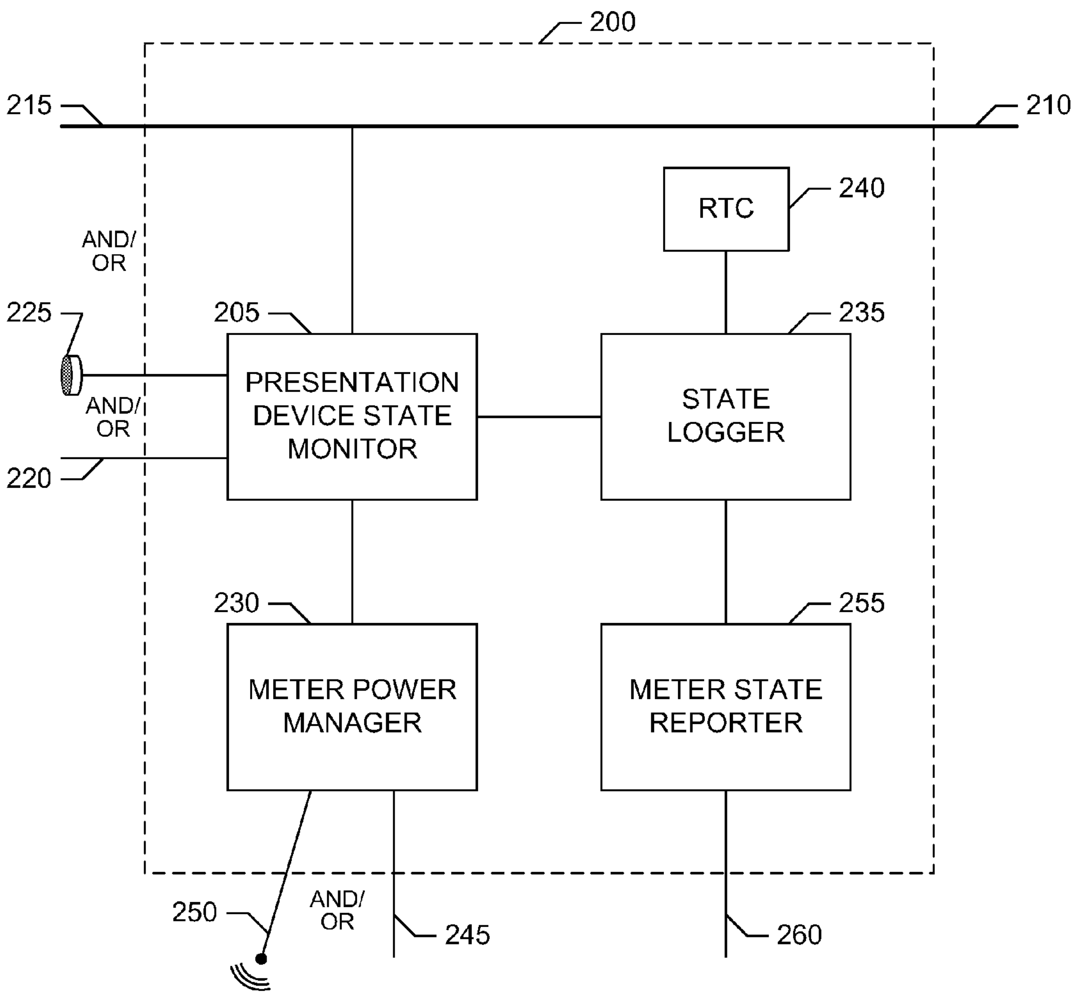

200
215
210
RTC
240
AND/
OR
225
205
235
PRESENTATION
DEVICE STATE
MONITOR
STATE
LOGGER
AND/
OR
220
230
255
METER POWER
MANAGER
METER STATE
REPORTER
250
AND/
OR
245
260

FIG. 2

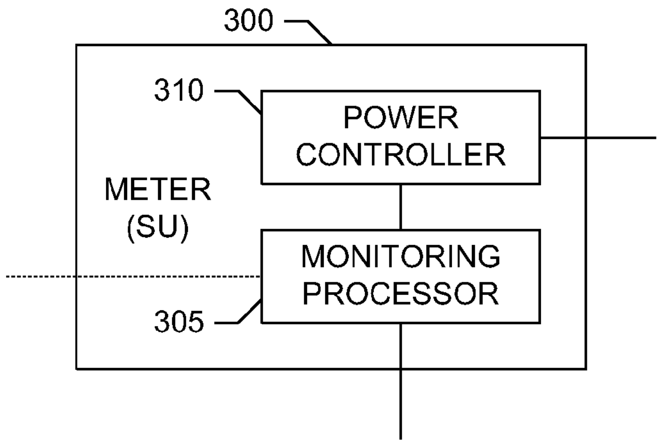


FIG. 3

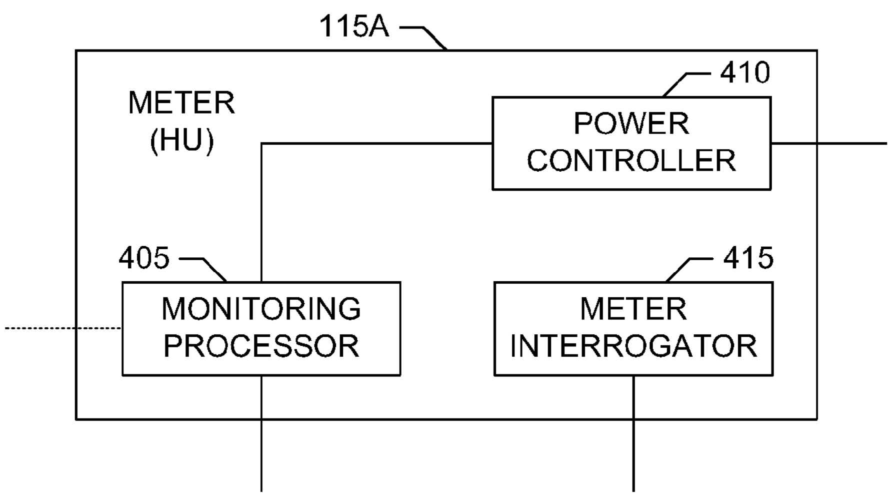


FIG. 4

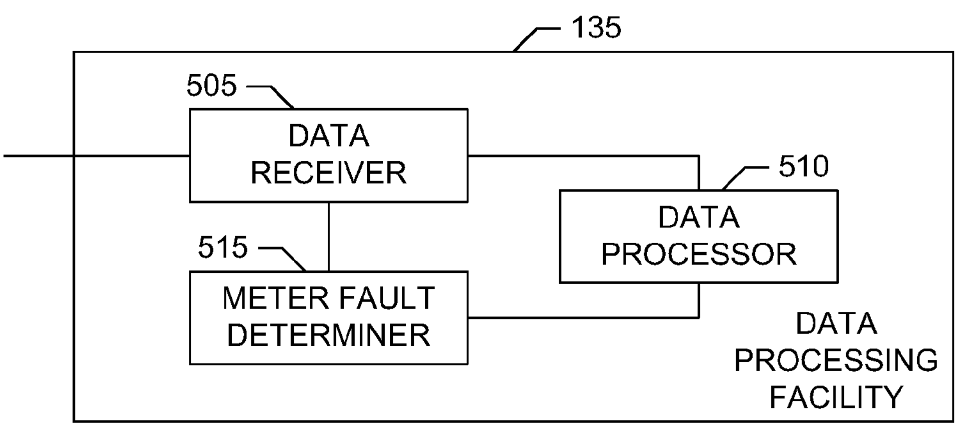


FIG. 5

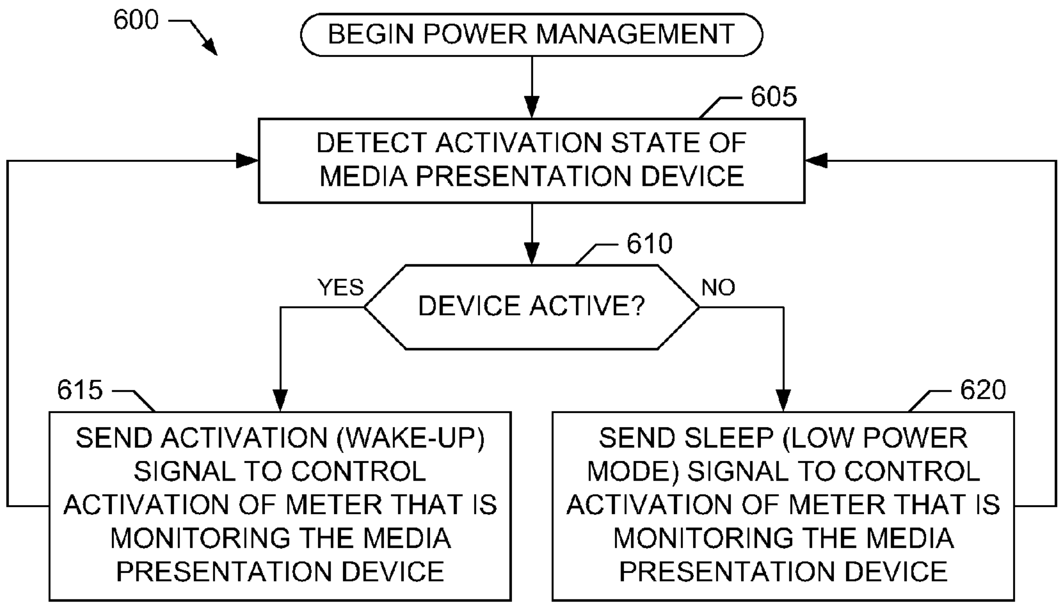

600
BEGIN POWER MANAGEMENT
605
DETECT ACTIVATION STATE OF MEDIA PRESENTATION DEVICE
610
DEVICE ACTIVE?
YES
NO
615
SEND ACTIVATION (WAKE-UP) SIGNAL TO CONTROL ACTIVATION OF METER THAT IS MONITORING THE MEDIA PRESENTATION DEVICE
620
SEND SLEEP (LOW POWER MODE) SIGNAL TO CONTROL ACTIVATION OF METER THAT IS MONITORING THE MEDIA PRESENTATION DEVICE

FIG. 6

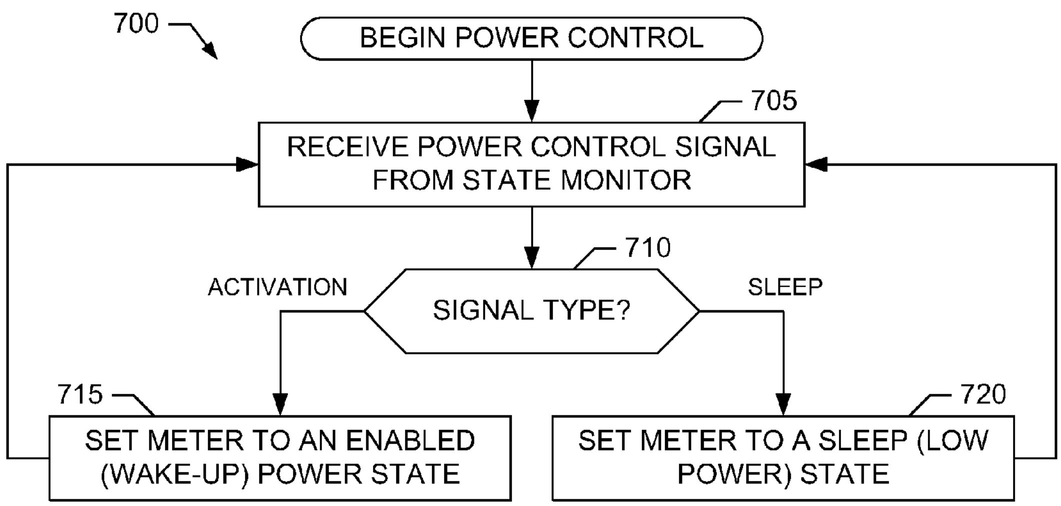

700
BEGIN POWER CONTROL
705
RECEIVE POWER CONTROL SIGNAL FROM STATE MONITOR
710
SIGNAL TYPE?
ACTIVATION
SLEEP
715
SET METER TO AN ENABLED (WAKE-UP) POWER STATE
720
SET METER TO A SLEEP (LOW POWER) STATE

FIG. 7

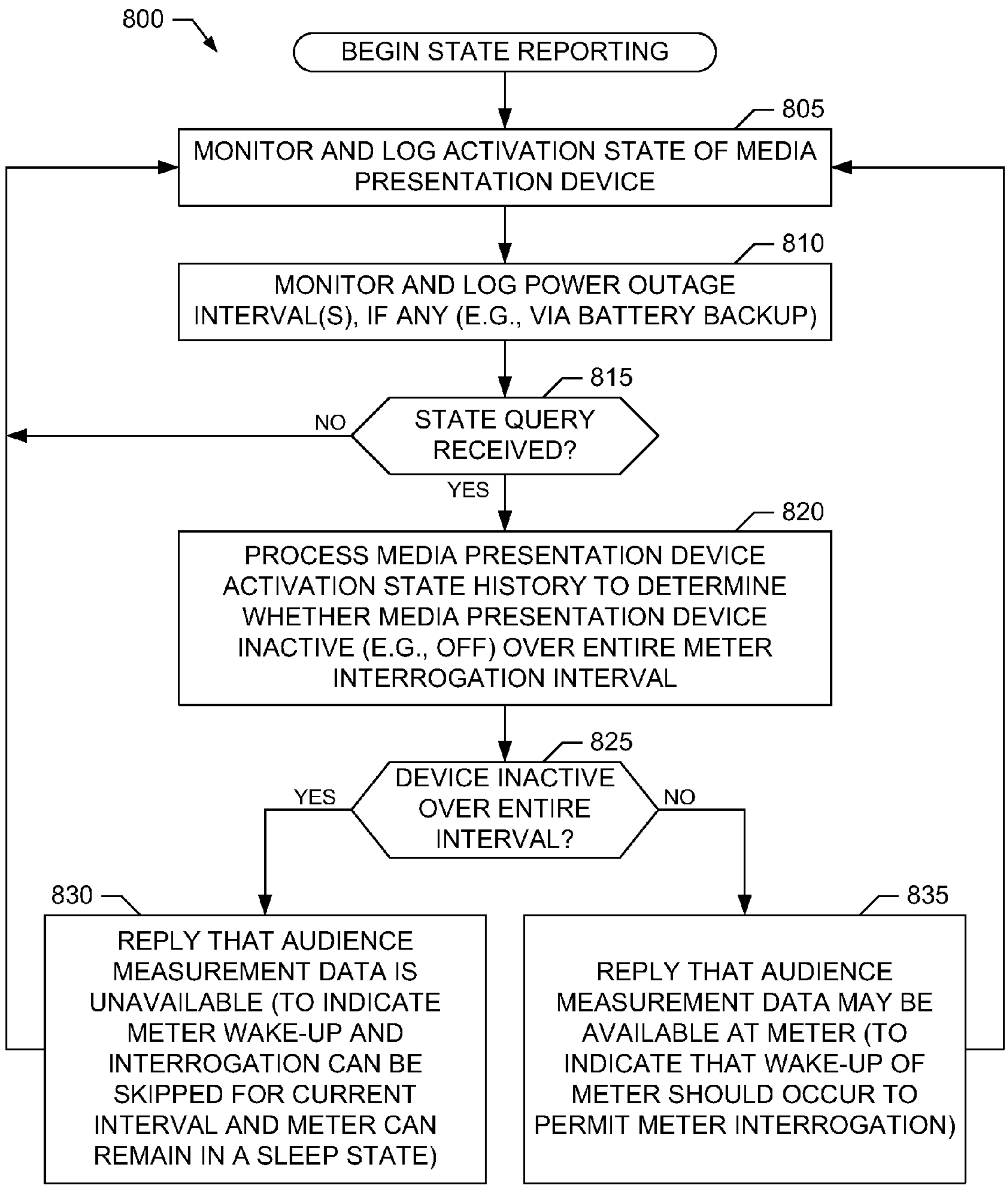

800
BEGIN STATE REPORTING
805
MONITOR AND LOG ACTIVATION STATE OF MEDIA PRESENTATION DEVICE
810
MONITOR AND LOG POWER OUTAGE INTERVAL(S), IF ANY (E.G., VIA BATTERY BACKUP)
815
STATE QUERY RECEIVED?
NO
YES
820
PROCESS MEDIA PRESENTATION DEVICE ACTIVATION STATE HISTORY TO DETERMINE WHETHER MEDIA PRESENTATION DEVICE INACTIVE (E.G., OFF) OVER ENTIRE METER INTERROGATION INTERVAL
825
DEVICE INACTIVE OVER ENTIRE INTERVAL?
YES
NO
830
REPLY THAT AUDIENCE MEASUREMENT DATA IS UNAVAILABLE (TO INDICATE METER WAKE-UP AND INTERROGATION CAN BE SKIPPED FOR CURRENT INTERVAL AND METER CAN REMAIN IN A SLEEP STATE)
835
REPLY THAT AUDIENCE MEASUREMENT DATA MAY BE AVAILABLE AT METER (TO INDICATE THAT WAKE-UP OF METER SHOULD OCCUR TO PERMIT METER INTERROGATION)

FIG. 8

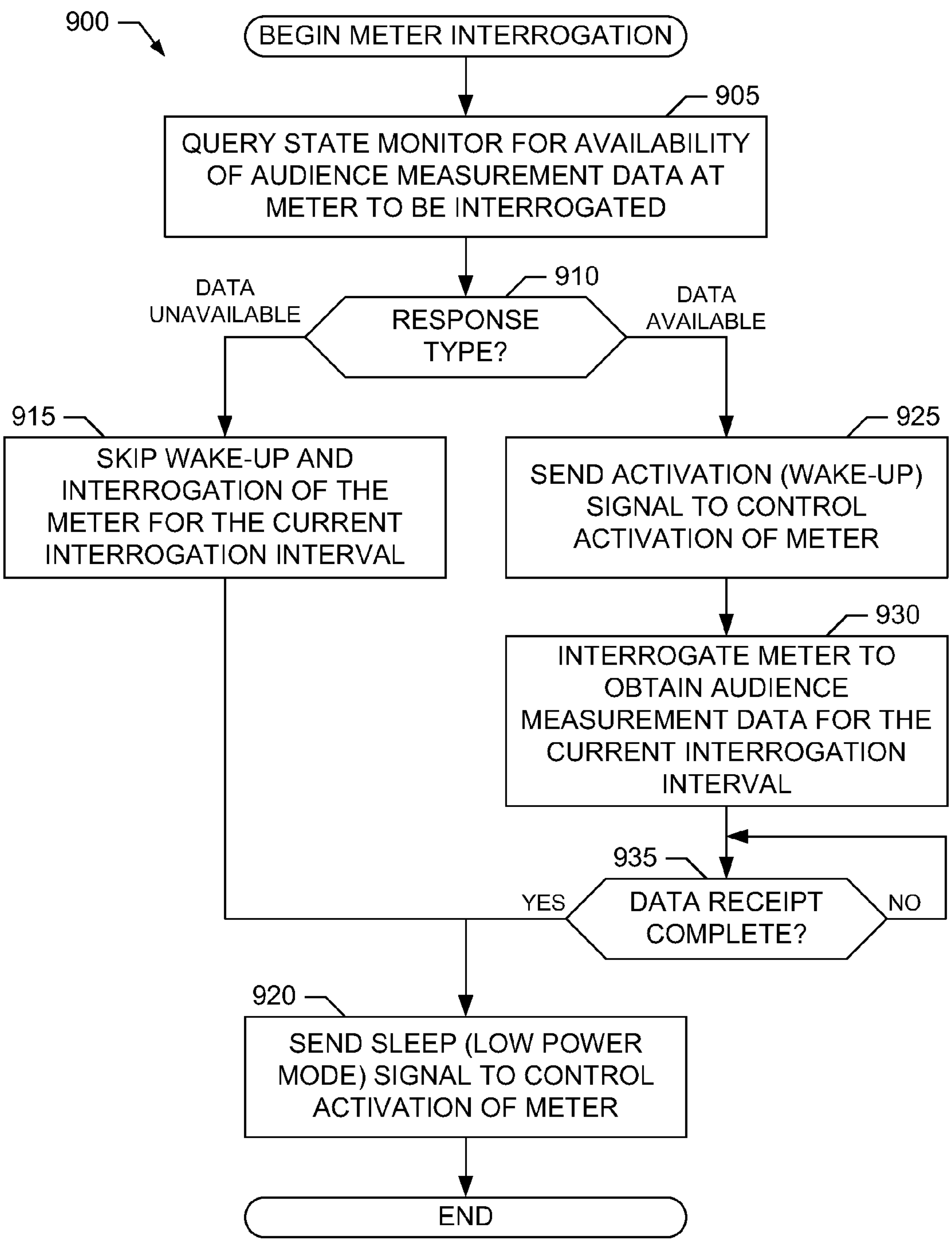

900
BEGIN METER INTERROGATION
905
QUERY STATE MONITOR FOR AVAILABILITY OF AUDIENCE MEASUREMENT DATA AT METER TO BE INTERROGATED
910
RESPONSE TYPE?
DATA UNAVAILABLE
DATA AVAILABLE
915
SKIP WAKE-UP AND INTERROGATION OF THE METER FOR THE CURRENT INTERROGATION INTERVAL
925
SEND ACTIVATION (WAKE-UP) SIGNAL TO CONTROL ACTIVATION OF METER
930
INTERROGATE METER TO OBTAIN AUDIENCE MEASUREMENT DATA FOR THE CURRENT INTERROGATION INTERVAL
935
DATA RECEIPT COMPLETE?
YES
NO
920
SEND SLEEP (LOW POWER MODE) SIGNAL TO CONTROL ACTIVATION OF METER
END

FIG. 9

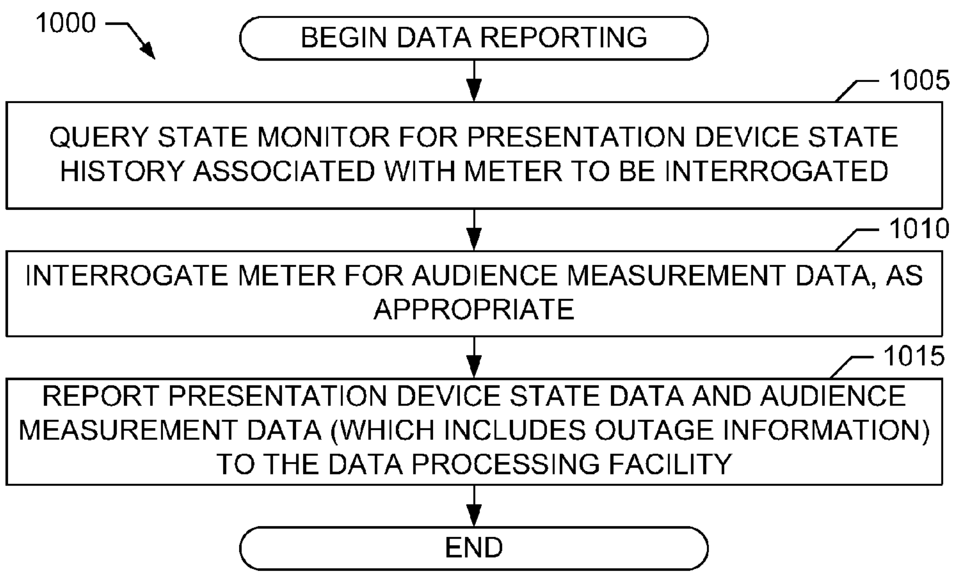

1000
BEGIN DATA REPORTING
1005
QUERY STATE MONITOR FOR PRESENTATION DEVICE STATE HISTORY ASSOCIATED WITH METER TO BE INTERROGATED
1010
INTERROGATE METER FOR AUDIENCE MEASUREMENT DATA, AS APPROPRIATE
1015
REPORT PRESENTATION DEVICE STATE DATA AND AUDIENCE MEASUREMENT DATA (WHICH INCLUDES OUTAGE INFORMATION) TO THE DATA PROCESSING FACILITY
END

FIG. 10

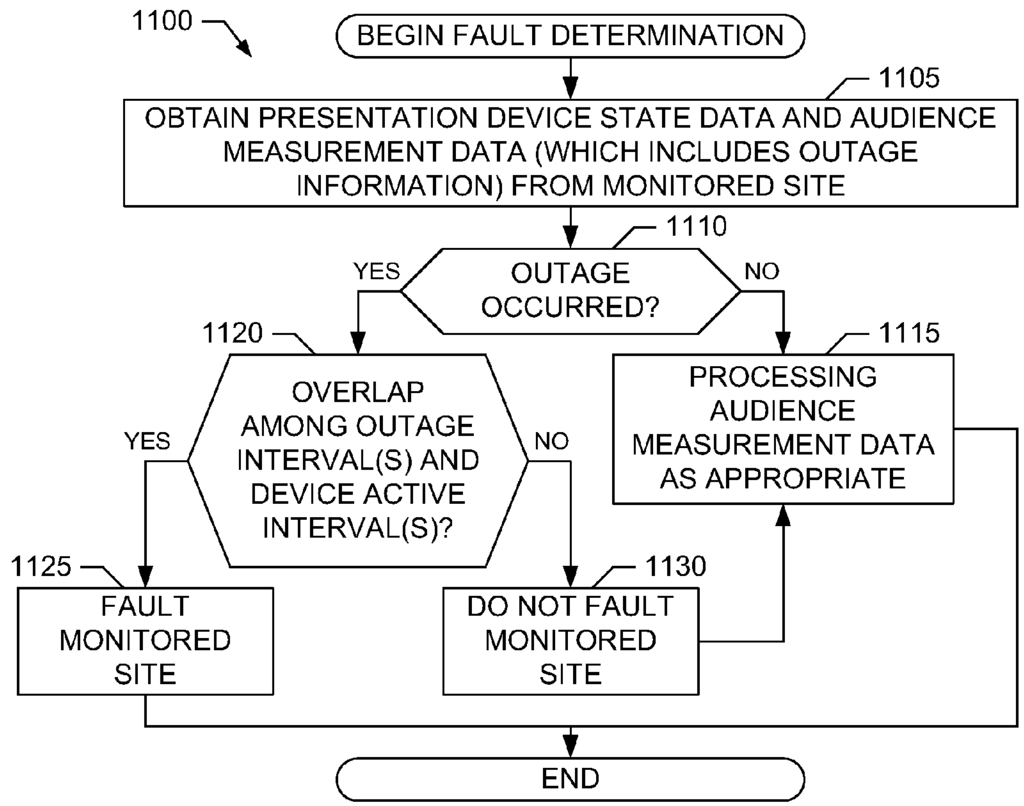

1100
BEGIN FAULT DETERMINATION
1105
OBTAIN PRESENTATION DEVICE STATE DATA AND AUDIENCE MEASUREMENT DATA (WHICH INCLUDES OUTAGE INFORMATION) FROM MONITORED SITE
1110
OUTAGE OCCURRED?
YES
NO
1120
OVERLAP AMONG OUTAGE INTERVAL(S) AND DEVICE ACTIVE INTERVAL(S)?
1115
PROCESSING AUDIENCE MEASUREMENT DATA AS APPROPRIATE
YES
NO
1125
FAULT MONITORED SITE
1130
DO NOT FAULT MONITORED SITE
END

FIG. 11

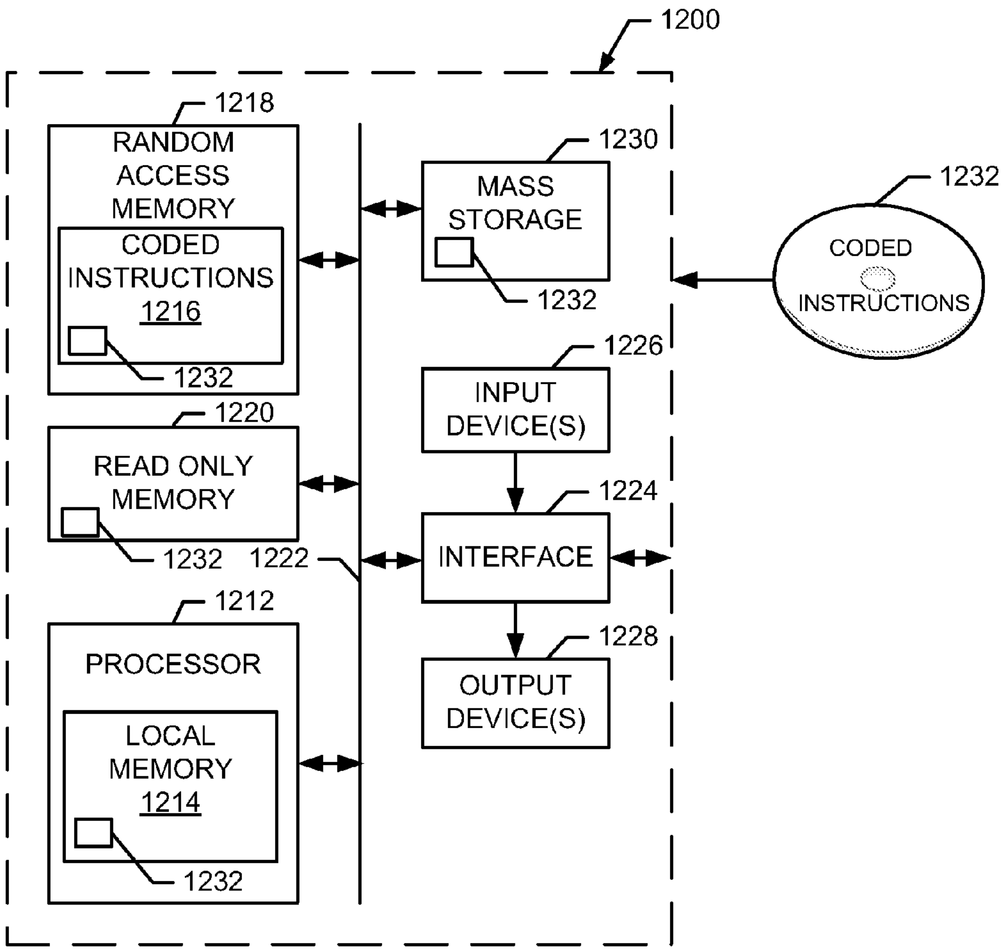

1200
1218
RANDOM ACCESS MEMORY
CODED INSTRUCTIONS 1216
1232
1220
READ ONLY MEMORY
1232
1222
1212
PROCESSOR
LOCAL MEMORY 1214
1232
1230
MASS STORAGE
1232
1226
INPUT DEVICE(S)
1224
INTERFACE
1228
OUTPUT DEVICE(S)
1232
CODED INSTRUCTIONS

FIG. 12

POWER MANAGEMENT FOR AUDIENCE MEASUREMENT METERS

FIELD OF THE DISCLOSURE

This disclosure relates generally to audience measurement and, more particularly, to power management for audience measurement meters.

BACKGROUND

Prior audience measurement systems include audience measurement meters that may operate continuously to ensure accurate monitoring of monitored media presentation devices, which may present media content at any time. As such, an audience measurement meter in one of these prior systems may consume power continuously, even when the associated media presentation device being monitored is inactive. Furthermore, in such a prior system, measurement data provided by the audience measurement meter may be faulted (e.g., considered invalid and/or discarded) for an entire monitoring period, such as an entire day, if the audience measurement meter experiences any loss of power and/or other outage for any duration during the monitoring period.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is block diagram of an example audience measurement system employing power management for audience measurement meters as described herein.

FIG. **2** is a block diagram of an example state monitor that may be used to implement the example audience measurement system of FIG. **1**.

FIG. **3** is a block diagram of a first example audience measurement meter that may be used to implement the example audience measurement system of FIG. **1**.

FIG. **4** is a block diagram of a second example audience measurement meter that may be used to implement the example audience measurement system of FIG. **1**.

FIG. **5** is a block diagram of an example data processing facility that may be used to implement the example audience measurement system of FIG. **1**.

FIG. **6** is a flowchart representative of example machine readable instructions that may be executed to implement power management processing in the example state monitor of FIG. **2**.

FIG. **7** is a flowchart representative of example machine readable instructions that may be executed to implement power control processing in the first example audience measurement meter of FIG. **3** and/or the second example audience measurement meter of FIG. **4**.

FIG. **8** is a flowchart representative of example machine readable instructions that may be executed to implement state reporting in the example state monitor of FIG. **2**.

FIG. **9** is a flowchart representative of example machine readable instructions that may be executed to implement meter interrogation processing in the second example audience measurement meter of FIG. **4**.

FIG. **10** is a flowchart representative of example machine readable instructions that may be executed to implement data reporting in the second example audience measurement meter of FIG. **4**.

FIG. **11** is a flowchart representative of example machine readable instructions that may be executed to implement fault determination processing in the example data processing facility of FIG. **5**.

FIG. **12** is a block diagram of an example processing system that may execute the example machine readable instructions of FIGS. **6-10** and/or **11** to implement the example audience measurement system of FIG. **1**, the example state monitor of FIG. **2**, the first example audience measurement meter of FIG. **3**, the second example audience measurement meter of FIG. **4** and/or the example data processing facility of FIG. **5**.

DETAILED DESCRIPTION

Power management methods, apparatus and articles of manufacture for audience measurement meters are disclosed herein. An example power management method disclosed herein includes determining an activation state of a media presentation device, and controlling activation of an audience measurement meter, which is to monitor the media presentation device, based on the activation state of the media presentation device. In some examples, the activation state of the media presentation device is determined based on measuring power consumption of the media presentation device. In some examples, the activation state of the media presentation device is determined based on monitoring an audio output of the media presentation device. In some examples, controlling activation of the audience measurement meter includes sending a wake-up signal to the audience measurement meter in response to determining that the media presentation device is in an active state, and sending a sleep signal to the audience measurement meter in response to determining that the media presentation device is in an inactive state. In some examples, controlling activation of the audience measurement meter includes determining whether the media presentation device has been inactive over a time interval, and when the media presentation device has been inactive over the time interval, indicating that wake-up and interrogation of the audience measurement meter to obtain audience measurement data corresponding to the time interval can be skipped (e.g., to permit the audience measurement meter to remain in a sleep state).

Another example power management method disclosed herein includes obtaining presentation device state data representing an activation state of a media presentation device being monitored by an audience measurement meter. This example method also includes determining whether to fault audience measurement data reported by the audience measurement meter based on the presentation device state data and outage information determined from the audience measurement data. In some examples, determining whether to fault the audience measurement data includes determining that the audience measurement data is to be faulted when a first time interval over which the audience measurement data indicates an outage occurred overlaps a second time interval over which the presentation device state data indicates the media presentation device was in an active state, and determining that the audience measurement data is not to be faulted when the first time interval does not overlap the second interval. In some examples, the presentation device state data is determined by a state monitor that is separate from the audience measurement meter that determined the audience measurement data.

In at least some prior audience measurement systems, audience measurement meters operate continuously to ensure accurate monitoring of media content presented by monitored media presentation devices at any time. However, because media presentation devices are often inactive for substantial periods of time, such as overnight during normal sleeping hours, such continuous operation of these prior audience

measurement meters can result in unnecessary and/or wasteful power consumption. In contrast to such prior systems, example power management methods, apparatus and articles of manufacture disclosed herein enable an audience measurement meter to be activated (e.g., woken-up) and deactivated (e.g., placed in sleep state) corresponding to a detected activation state of a media presentation device being monitored by the audience measurement meter, thereby improving energy efficiency of the audience measurement meter. Additionally or alternatively, example power management methods, apparatus and articles of manufacture disclosed herein can determine whether an audience measurement meter has audience measurement data to report and, thus, is to be woken up for interrogation, or whether the audience measurement meter does not have audience measurement data to report and, thus, can be permitted to continue operation in a low-power sleep state, which can also yield efficient energy consumption.

Furthermore, in at least some prior audience measurement systems, audience measurement data provided by an audience measurement meter may be faulted (e.g., invalidated, discarded, etc.) for an entire monitoring period, such as an entire day, if the audience measurement meter experiences any loss of power or other outage (e.g., such as a communication outage) for any duration during the monitoring period. In such prior systems, the audience measurement data is faulted under these circumstances because the data processing facility that is to process the audience measurement data cannot determine whether or not a media presenting device being monitored by the audience measurement meter may still have presented media content during the gap(s) in the measurement data resulting from the power loss experienced by the audience measurement meter. In contrast to such prior systems, example power management methods, apparatus and articles of manufacture disclosed herein enable a data processing facility to determine whether the media presenting device being monitored by the audience measurement meter was active or inactive during a power loss or other outage experienced by the audience measurement meter (e.g., where a power loss or other outage is indicated by a gap in the audience measurement data reported by the audience measurement meter). Moreover, if the media presenting device is determined to have been inactive while the audience measurement meter experienced the power loss or other outage, no media content could have been presented during the gap(s) in the measurement data resulting from the power loss or other outage and, thus, the data processing facility can determine that faulting the audience measurement data obtained from the audience measurement meter is unnecessary.

Turning to the figures, a block diagram of an example audience measurement system **100** employing power management for audience measurement meters as disclosed herein is illustrated in FIG. **1**. The audience measurement system **100** of the illustrated example includes three example monitored sites **105**A, **105**B and **105**C, which may reside at the same location (e.g., such as an audience members home) or at two or more different locations. The monitored site **105**A includes an example media presentation device **110**A and an example audience measurement meter **115**A to monitor media content presented by the media presentation device **110**A. Likewise, the monitored site **105**B includes an example media presentation device **110**B and an example audience measurement meter **115**B to monitor media content presented by the media presentation device **110**B, and the monitored site **105**C includes an example media presentation device **110**C and an example audience measurement meter **115**C to monitor media content presented by the media presentation device **110**C. To support power management for the audience measurement meters **115**A-C in accordance with the examples described herein, the monitored sites **105**A-C include respective example state monitors **120**A-C, which are described in greater detail below. Although the audience measurement system **100** of the illustrated example includes three monitored sites **105**A-C, audience measurement meter power management as described herein can be used in audience measurement systems **100** having any number of monitored sites **105**A-C.

The example media presentation devices **110**A-C can each correspond to any type of audio, video and/or multimedia presentation device capable of presenting media content audibly and/or visually. For example, one or more of the media presentation devices **110**A-C can correspond to a respective television and/or display device that supports the National Television Standards Committee (NTSC) standard, the Phase Alternating Line (PAL) standard, the Systeme Electronique pour Couleur avec Mémoire (SECAM) standard, a standard developed by the Advanced Television Systems Committee (ATSC), such as high definition television (HDTV), a standard developed by the Digital Video Broadcasting (DVB) Project, etc. As another example, one or more of the media presentation devices **110**A-C can correspond to a multimedia computer system, a personal digital assistant, a cellular/mobile smartphone, a radio, etc.

The audience measurement meters **115**A-C can each correspond to any type of metering device capable of monitoring media content presented by the respective media presentation devices **110**A-C. In FIG. **1**, the connections between the audience measurement meters **115**A-C and the respective media presentation devices **110**A-C are represented by dashed lines because the audience measurement meters **115**A-C may support invasive monitoring involving one or more physical connections to the media presentation devices **110**A-C, and/or non-invasive monitoring not involving any physical connection to the media presentation devices **110**A-C. For example, one or more of the audience measurement meters **115**A-C can process audio signals obtained from a microphone and/or a direct cable connection to detect content and/or source identifying audio codes and/or audio watermarks embedded in audio portion(s) of the media content presented by the respective one or more of the media presentation devices **110**A-C. Additionally or alternatively, one or more of the audience measurement meters **115**A-C can process video signals obtained from a camera and/or a direct cable connection to detect content and/or source identifying video codes and/or video watermarks embedded in video portion(s) of the media content presented by the respective one or more of the media presentation devices **110**A-C. Additionally or alternatively, one or more of the audience measurement meters **115**A-C can process the aforementioned audio signals and/or video signals to generate respective audio and/or video signatures from the media content presented by the respective one or more of the media presentation devices **110**A-C, which can be compared to reference signatures to perform source and/or content identification. Other types of audience measurement meters **115**A-C can also be supported by the example audience measurement meter power management techniques described herein.

In the audience measurement system **100** of FIG. **1**, the media content monitoring functionality described above is referred to as site unit (SU) functionality to indicate that the scope of such functionality is limited to the particular monitored site **105**A-C in which the respective audience measurement meter **115**A-C resides. Additionally, the audience measurement meter **115**A of the illustrated example implements

home unit (HU) functionality. Home unit functionality involves data logging and forwarding functionality in which the home unit (e.g., the audience measurement meter **115**A) interrogates the other site units (e.g., the audience measurement meters **115**B-C) at a particular location (e.g., a subscriber household) to obtain the audience measurement data determined by each of the site units. Audience measurement data can include, for example, media content identification information, source identification information, content presentation duration information, audience member interaction information (e.g., such as channel and volume change information, digital video recorder command selections, etc.), audience member identification information, etc. The home unit then stores the audience measurement data obtained from the site units, and forwards this audience measurement data to a data processing facility for post-processing (e.g., to credit ratings for particular programs, verify commercial advertisement broadcasts, etc.).

For example, in the audience measurement system **100**, the audience measurement meter **115**A provides home unit functionality and, as such, interrogates the audience measurement meters **115**B and **115**C via an example network **125** to obtain audience measurement data from the monitored sites **105**B and **105**C, respectively. The audience measurement meter **115**A then stores and reports this audience measurement data, as well as the audience measurement data determined by the audience measurement meter **115**A itself for the monitored site **105**A, via an example network **130** to an example data processing facility **135**. The data processing facility **135** validates the reported audience measurement data, as described in greater detail below, and performs any appropriate post-processing of this data. In the illustrated example, the networks **125** and **130** can correspond to any type of wired or wireless data network, or combination thereof. Also, the networks **125** and **130** can correspond to portions of a common network, or can correspond to distinct networks.

As noted above, the audience measurement system **100** includes the state monitors **120**A-C to support audience measurement meter power management as described herein. Generally, an example state monitor as described herein monitors an activation state of a respective media presentation device and controls activation of a respective audience measurement meter based on the monitored activation state of the respective media presentation device. For example, the state monitor can set its respective audience measurement meter to an enabled state (e.g., an active mode) when the respective media presentation device is determined to be active (e.g., on), and can set its respective audience measurement meter to a sleep state (e.g., a low power mode) when the respective media presentation device is determined to be inactive (e.g., off). Additionally or alternatively, the state monitor can indicate to a home unit that interrogation of its respective audience measurement meter can be skipped when the respective media presentation device is determined to have been inactive (e.g., off) during an interrogation interval (e.g., or other such measurement interval). Additionally or alternatively, the state monitor can determine and report presentation device state data representing the monitored activation state of its respective media presentation device, and which includes time information specifying an initiation time and duration for each monitored state, for use by a data processing facility when validating audience measurement data reported by the respective audience measurement meter.

For example, in the audience measurement system **100**, the state monitor **120**A is electrically coupled to a power source **140**A. In the illustrated example, the state monitor **120**A couples the power source **140**A to the media presentation device **110**A, which is represented by a line **145**A. As such, the state monitor **120**A can monitor the power consumption (e.g., by monitoring current consumption) associated with the power source **140**A to determine the activation state (e.g., active/on or inactive/off) of the media presentation device **110**A. Based on the monitored activation state of the media presentation device **110**A, the state monitor **120**A can control activation of the audience measurement meter **115**A, for example, by causing the audience measurement meter **115**A to enter an enabled state when the state monitor **120**A determines that the media presentation device **110**A is active, and by causing the audience measurement meter **115**A to enter a sleep state when the state monitor **120**A determines that the media presentation device **110**A is inactive. In the example of FIG. **1**, the state monitor **120**A employs a physical (e.g., wired/cabled) connection **150**A to control the audience measurement meter **115**A in this manner. In the illustrated example, the state monitor **120**A is also connected to the network **125** and, thus, can report presentation device state data representing the monitored activation state of the media presentation device **110**A, and which includes time information specifying an initiation time and duration for each monitored state, to the home unit audience measurement meter **115**A for subsequent reporting to the data processing facility **135**. As described in greater detail below, the data processing facility **135** uses this reported presentation device state data, along with outage information determined from the audience measurement data reported by the meter **115**A, to determine whether to fault or validate the audience measurement data reported by the meter **115**A.

Similarly, the state monitor **120**B is electrically coupled to a power source **140**B. In the illustrated example, the state monitor **120**B couples the power source **140**B to the media presentation device **110**B, which is represented by a line **145**B. As such, like the state monitor **120**A, the state monitor **120**B can monitor the power consumption (e.g., by monitoring current consumption) associated with the power source **140**B to determine the activation state (e.g., active/on or inactive/off) of the media presentation device **110**B. Based on the monitored activation state of the media presentation device **110**B, the state monitor **120**B can control activation of the audience measurement meter **115**B, for example, by causing the audience measurement meter **115**B to enter an enabled state when the state monitor **120**B determines that the media presentation device **110**B is active, and by causing the audience measurement meter **115**B to enter a sleep state when the state monitor **120**B determines that the media presentation device **110**B is inactive. However, unlike the wired connection **150**A employed by the state monitor **120**A, the state monitor **120**B employs a wireless connection **150**B to control the audience measurement meter **115**B in this manner. Also, like the state monitor **120**A, the state monitor **120**B is connected to the network **125** and, thus, can report presentation device state data representing the monitored activation state of the media presentation device **110**B, and which includes time information specifying an initiation time and duration for each monitored state, to the home unit audience measurement meter **115**A for subsequent reporting to the data processing facility **135**. As described in greater detail below, the data processing facility **135** uses this reported presentation device state data, along with outage information determined from the audience measurement data reported by the meter **115**B, to determine whether to fault or validate the audience measurement data reported by the meter **115**B. Additionally or alternatively, in some examples the state monitor **120**B communicates with the home unit audience measurement meter **115**A via the network **125** to indicate, based on the

monitored activation state of the media presentation device **110**B, whether interrogation of the audience measurement meter **115**B to retrieve its audience measurement data can be skipped during a current interrogation interval (e.g., or other such measurement interval).

In the illustrated example of FIG. **1**, the state monitor **120**C is electrically coupled to a power source **140**C for powering the state monitor **120**C. However, unlike the arrangements of the state monitors **120**A-B, the state monitor **120**C of the illustrated example does not couple the power source **140**C to the media presentation device **110**C. Instead, the power source **145**C for the media presentation device **110**C may be separate from the power source **140**C powering the state monitor **120**C. As such, the state monitor **120**C monitors one or more other operational aspects of the media presentation device **110**C, such as by monitoring an audio signal **155** output from the media presentation device **110**C using an example sensor **160**, to determine the activation state (e.g., active/on or inactive/off) of the media presentation device **110**C. Based on the monitored activation state of the media presentation device **110**C, the state monitor **120**C can control activation of the audience measurement meter **115**C, for example, by causing the audience measurement meter **115**C to enter an enabled state when the state monitor **120**C determines that the media presentation device **110**C is active, and by causing the audience measurement meter **115**C to enter a sleep state when the state monitor **120**C determines that the media presentation device **110**C is inactive. The state monitor **120**C, like the state monitor **120**B, employs a wireless connection **150**C to control the audience measurement meter **115**C in this manner. Also, like the state monitors **120**A-B, the state monitor **120**C is connected to the network **125** and, thus, can report presentation device state data representing the monitored activation state of the media presentation device **110**C, and which includes time information specifying an initiation time and duration for each monitored state, to the home unit audience measurement meter **115**A for subsequent reporting to the data processing facility **135**. As described in greater detail below, the data processing facility **135** uses this reported presentation device state data, along with outage information determined from the audience measurement data reported by the meter **115**C, to determine whether to fault or validate the audience measurement data reported by the meter **115**C. Additionally or alternatively, in some examples the state monitor **120**C communicates with the home unit audience measurement meter **115**A via the network **125** to indicate, based on the monitored activation state of the media presentation device **110**C, whether interrogation of the audience measurement meter **115**C to retrieve its audience measurement data can be skipped during a current interrogation interval (e.g., or other such measurement interval).

A block diagram of an example state monitor **200** that may be used to implement, for example, any of the state monitors **120**A-C of FIG. **1** is illustrated in FIG. **2**. The example state monitor **200** of FIG. **2** includes an example presentation device state monitor **205** to monitor an activation state of a media presentation device, such as one of the media presentation devices **110**A-C. In the illustrated example, the state monitor **200** can be placed in-line with a power source (e.g., one of the power sources **140**A-B) such that the power source is electrically coupled from a power input **210** to a power output **215**. If the media presentation device is electrically coupled to the power output **215** to obtain power from the power source electrically coupled to the power input **210**, the presentation device state monitor **210** can determine the activation state of the media presentation device by monitoring

power consumption associated with power source electrically coupled to the power input **210**.

For example, the presentation device state monitor **205** can be calibrated with a first power consumption threshold (e.g., such as a first current consumption threshold) corresponding to a minimum expected power (current) consumption when the monitored media presentation device is in an active/on state, and/or a second power consumption threshold (e.g., such as a second current consumption threshold) corresponding to a maximum expected power (current) consumption when the monitored media presentation device is in an inactive/off state. During operation, the presentation device state monitor **205** can use any appropriate technique to monitor the monitored power (current) consumption associated with power source electrically coupled to the power input **210**, and then compare the monitored power (current) consumption with the first and/or second calibrated thresholds. In some examples, the presentation device state monitor **205** determines that the monitored media presentation device is in an active/on state if the monitored power (current) consumption is greater than the first threshold, and determines that the monitored media presentation device is in an inactive/off state if the monitored power (current) consumption is less than the second threshold. Alternatively, in some examples, the presentation device state monitor **205** determines that the monitored media presentation device is in the active/on state if the monitored power (current) consumption is greater than the first threshold, and determines that the monitored media presentation device is in the inactive/off state if the monitored power (current) consumption is less than the first threshold. Alternatively, in some examples, the presentation device state monitor **205** determines that the monitored media presentation device is in the active/on state if the monitored power (current) consumption is greater than the second threshold, and determines that the monitored media presentation device is in the inactive/off state if the monitored power (current) consumption is less than the second threshold.

Additionally or alternatively, the presentation device state monitor **205** can detect slope changes in measurements of power (current) consumption over time to determine when the monitored media presentation device has been switched from an inactive/off state to an active/on state. For example, if the presentation device state monitor **205** detects one or more positive slope changes corresponding to an increase in power (current) consumption over one or more respective (e.g., consecutive) measured time intervals, the presentation device state monitor **205** can determine that the monitored media presentation device has been switched from an inactive/off state to an active/on state. Conversely, if the presentation device state monitor **205** detects one or more negative slope changes corresponding to an decrease in power (current) consumption over one or more respective (e.g., consecutive) measured time intervals, the presentation device state monitor **205** can determine that the monitored media presentation device has been switched from an active/on state to an inactive/off state.

In some examples, the presentation device state monitor **205** can additionally or alternatively monitor a digital audio stream output by the monitored media presentation device and applied to a digital audio input **220** to determine the activation state of the monitored media presentation device. For example, for some media presentation devices, a digital audio stream is present whenever such a device is active/on, and the digital audio is absent whenever the device is inactive/off. For such media presentation devices, if the digital audio output of the monitored media presentation device is coupled to the digital audio input **220**, the presentation device state

monitor **205** can monitor the digital audio input **220** for the presence of a digital audio stream. If a digital audio stream is present, the presentation device state monitor **205** determines that the monitored media presentation device is in an active/on state. Otherwise, if the digital audio stream is absent, the presentation device state monitor **205** determines that the monitored media presentation device is in an inactive/off state.

In some examples, the presentation device state monitor **205** can additionally or alternatively monitor an audio signal emanating from the monitored media presentation device and received by an audio sensor **225**, such as a microphone **225**, to determine the activation state of the monitored media presentation device. For example, the presentation device state monitor **205** can monitor the output of the sensor **225** to detect the presence of an audio signal. If an audio signal is detected (e.g., based on a comparison with a signal energy threshold), the presentation device state monitor **205** determines that the monitored media presentation device is in an active/on state. Otherwise, if an audio signal is not detected, the presentation device state monitor **205** determines that the monitored media presentation device is in an inactive/off state. Additionally or alternatively, the presentation device state monitor **205** can use any one or more of the techniques described in U.S. Pat. No. 7,882,514, entitled "Display Device On/Off Detection Methods and Apparatus" and issued on Feb. 1, 2011, to process an audio signal output from the sensor **225** to determine an activation state of a monitored media presentation device. Additionally or alternatively, the presentation device state monitor **205** can employ any one or more of the techniques described in U.S. Pat. No. 7,882,514 to process output signals other than, or in addition to, an audio signal to determine an activation state of a monitored media presentation device.

The example state monitor **200** of FIG. **2** also includes an example meter power manager **230** to perform power management for an audience measurement meter (e.g., such as one of the audience measurement meters **115**A-C) based on the current activation state of an associated media presentation device (e.g., such as one of the associated media presentation devices **110**A-C) as determined by the presentation device state monitor **205**. Table 1 illustrates an example set of operating states for an example audience measurement meter. Although the example set of operating states listed in Table 1 correspond to a meter implementation based on Intel's® Atom™ chipset, this list of operating states is representative of typical states in which other processors can be configured to operate. Furthermore, power management for audience measurement meters as described herein is not limited to being used with meters having the operating states listed in Table 1, but can be used with any meter having two or more operating states in which at least one state corresponds to an enabled (e.g., on) state, and at least one other operating state corresponds to a sleep or other lower power state.

TABLE 1

State	Description
S0	Enabled state; system is on; central processing unit (CPU) is fully running
S1	CPU is stopped; random access memory (RAM) is refreshed; system is running in a first low power mode
S2	CPU is off (no power); RAM is refreshed; system is running in a second low power mode that is lower than the first low power mode
S3	CPU is off (no power); RAM is in slow refresh state; power supply is in a reduced power mode, yielding a third low power mode lower than the first and second low power modes
S4	Hardware is completely off, but system memory has been saved to disk
S5	Hardware is completely off; operating system has shutdown; system memory is not saved to disk; system if off and a reboot is required to return to a working state

Turning to Table 1, state S3 corresponds to a sleep (or low power) state into which a corresponding audience measurement meter (e.g., such as one of the audience measurement meters **115**A-C) can be set in response to application of an appropriate sleep signal (or, equivalently, an appropriate sleep command). From state S3 or another low power state, the audience measurement meter can be woken or, in other words, configured to transition to state S0, which corresponds to an enabled (on) state, in response to application of an appropriate wake-up signal (or, equivalently, an appropriate wake-up command). Examples of appropriate wake-up signals/commands that can be used to wake-up the audience measurement meter from the sleep state (S3) include one or more of: (1) an RTC alarm signal that causes the audience measurement meter to transition to the enabled state (S0) upon occurrence of a configured real time clock (RTC) alarm; (2) a wake-on-LAN signal that causes the audience measurement meter to transition to the enabled state (S0) upon detection of data at a local area network (LAN) interface; (3) wake-on-WLAN signal that causes the audience measurement meter to transition to the enabled state (S0) upon detection of data at a wireless LAN (WLAN) interface; (4) a wake-on-USB signal that causes the audience measurement meter to transition to the enabled state (S0) upon detection of data at a universal serial bus (USB) interface; etc. Another example of a wake-up signal/command includes asserting a signal on an appropriately configured input/output (I/O) pin such that asserting the signal on the I/O pin causes an interrupt to occur, which transitions the meter from a sleep state to an enabled state. Yet another example of a wake-up signal/command includes sending a message over an appropriately configured bus which, when the message is detected, causes the meter to transition from a sleep state to an enabled state.

In some examples, the meter power manager **230** uses the current activation state of a monitored media presentation device as determined by the presentation device state monitor **205** to determine whether to send a sleep signal or an appropriate wake-up signal to an associated audience measurement meter. For example, assume without loss of generality that the example state monitor **200** of FIG. **2** is used to implement the state monitor **120**A of FIG. **1**. In such an example, further assume that the media presentation device **110**A in inactive/off, and the audience measurement meter **115**A is in the sleep state (S3). When the presentation device state monitor **205** detects that the media presentation device **110**A has transitioned to an active/on state, the meter power manager **230** sends an appropriate wake-up signal to the audience measurement meter **115**A to cause the meter **115**A to transition to the enabled state (S0). For example, the meter power manager **230** can send a wake-on-LAN signal, send a wake-on-USB signal, send an appropriate bus message and/or assert an appropriate I/O pin via a physical (e.g., wired/cabled) power control connection **245**. Additionally or alternatively, the meter power manager **230** can send a wake-on-WLAN signal via a wireless power control connection **250**. Then, assume that sometime later the presentation device state monitor **205** detects that the media presentation device **110**A has transitioned to an inactive/off state. In response, the meter power

manager **230** sends an appropriate sleep signal to the audience measurement meter **115**A via one or both of the connections **245** and/or **250** to cause the meter **115**A to transition to the sleep state (S3).

The example state monitor **200** of FIG. **2** further includes an example state logger **235** to log presentation device state data representing the monitored activation state of the media presentation device as determined by the presentation device state monitor **205**. For example, the presentation device state data can include information indicating occurrences of activation state changes and the resulting activation state (e.g., active/on, inactive/off, etc.) of the monitored media presentation device. Additionally, in the illustrated example, the state monitor **200** of FIG. **2** includes an example real time clock (RTC) **240**, or similar clocking/timing mechanism, capable of tracking absolute or relative time. The state logger **235** uses the RTC **240** to track the initiation time of each monitored change in the activation state of the monitored media presentation device, and the duration for each resulting monitored activation state of the monitored media presentation device. In some examples, this timing information is included in the presentation device state data logged by the state logger **235**. Furthermore, the state monitor **200** can include a battery and/or other backup power supply (not shown) to permit the presentation device state monitor **205** to continue monitoring the activation state of a particular media presentation device, and to permit the state logger **235** to continue logging the presentation device state data, during power outage events. The presentation device state data can be stored in any data format, such as one or more data structures, database entries, etc.

Additionally, the example state monitor **200** of FIG. **2** includes an example meter state reporter **255** to receive and reply to state queries received via an interface **260** from, for example, a home unit (e.g., such as the home unit audience measurement meter **115**A). Referring to the audience measurement system **100** of FIG. **1**, in some examples, the home unit audience measurement meter **115**A queries the site unit audience measurement meters **115**B and **115**C at regular interrogation intervals to obtain their stored audience measurement data. If a particular site unit audience measurement meter **115**B-C is in a sleep state (e.g., state S3) at the time of an interrogation query, the particular site unit audience measurement meter **115**B-C will wake-up and transition to an enabled state (e.g., state S0) in response to being interrogated. However, if the respective media presentation device **110**B being monitored by the particular site unit audience measurement meter **115**B-C has been inactive/off during the entire interrogation/measurement interval associated with the interrogation query (e.g., due to a power outage, lack of device use, etc.), the particular site unit audience measurement meter **115**B-C will have no audience measurement data to report. In such circumstances, causing the particular site unit audience measurement meter **115**B-C to wake-up to respond to a received interrogation query is unnecessary and can result in reduced energy efficiency of the meter and/or reduce backup battery life (e.g., if the meter **115**B-C is operating on backup battery power during a power outage and is in a sleep state to conserve power, but is then woken unnecessarily).

To avoid querying a particular site unit audience measurement meter **115**B-C when it has no audience measurement data to report, the home unit audience measurement meter **115**A can first send a state query to the state monitor **120**B-C associated with the particular site unit audience measurement meter **115**B-C to obtain information regarding the activation state of the respective media presentation device **110**B-C during the interrogation/measurement interval. If the state monitor **120**B-C replies with an indication that the respective media presentation device **110**B-C has been inactive during the entire interrogation/measurement interval and, thus, audience measurement data is unavailable, the home unit audience measurement meter **115**A can skip interrogation of the particular site unit audience measurement meter **115**B-C during the current interrogation/measurement interval. If, however, the state monitor **120**B-C replies with an indication that the respective media presentation device **110**B-C has been active during at least part of the interrogation/measurement interval and, thus, audience measurement data may be available, the home unit audience measurement meter **115**A can proceed with interrogating the particular site unit audience measurement meter **115**B-C to obtain its audience measurement data for the current interrogation/measurement interval.

Returning to FIG. **2**, the meter state reporter **255** can receive such state queries from a home unit and process the presentation device state data logged by the state logger **235** to determine whether a media presentation device being monitored by the state monitor **200** has been inactive or active during the current interrogation/measurement interval (e.g., since the last state query was received). If the presentation device state data indicates that the monitored media presentation device has been inactive during the current interrogation/measurement interval, the meter state reporter **255** can reply to the state query with an indication that no audience measurement data is available (and, thus, interrogation of the associated audience measurement meter can be skipped) because the media presentation device has been inactive. However, if the presentation device state data indicates that the monitored media presentation device has been active during at least part of the current interrogation/measurement interval, the meter state reporter **255** can reply to the state query with an indication that audience measurement data may be available (and, thus, interrogation of the associated audience measurement meter should be performed) because the media presentation device has been active.

In some examples, the meter state reporter **255** additionally or alternatively supports receiving and responding to queries for the presentation device state data logged by the state logger **235**. For example, a home unit (e.g., such as the home unit audience measurement meter **115**A) can query the state monitor **200** to obtain its presentation device state data for reporting to a data processing facility (e.g., such as the data processing facility **135**). As described in greater detail below, the a data processing facility can then use this presentation device state data to determine whether to fault or validate audience measurement data being reported by an audience measurement meter associated with the state monitor **200**.

A block diagram of an example site unit audience measurement meter **300** that may be used to implement, for example, any of the site unit audience measurement meters **115**B-C of FIG. **1** is illustrated in FIG. **3**. The example site unit audience measurement meter **300** of FIG. **3** includes an example monitoring processor **305** to monitor media content presented by a media presentation device (e.g., such as one of the media presentation devices **110**B-C) using any invasive or non-invasive monitoring technique, such as one or more of the monitoring techniques described above in connection with audience measurement system **100** of FIG. **1**.

The example site unit audience measurement meter **300** of FIG. **3** also includes an example power controller **310** to control power consumption of the meter **300**, including power consumption associated with the monitoring processor **305**, in response to signals/commands received from a state monitor, such as one of the state monitors **120**B-C or **200** described above. For example, assume that the monitoring

processor **305** supports operating states such as those listed in Table 1. Then, in response to receiving a sleep signal/command from an associated state monitor, the power controller **310** of the site unit audience measurement meter **300** can configure the monitoring processor **305** to enter a sleep state, such as the state S3 of Table 1, or one of the other low power states. Furthermore, in response to receiving an activation (e.g., wake-up) signal/command (e.g., such as a wake-on-LAN signal, a wake-on-USB signal, a wake-on-WLAN signal, etc.) from the associated state monitor, the power controller **310** can configure the monitoring processor **305** to enter an enabled state, such as the state S0 of Table 1.

A block diagram of an example implementation of the home unit audience measurement meter **115**A of FIG. **1** is illustrated in FIG. **4**. The example home unit audience measurement meter **115**A of FIG. **4** includes an example monitoring processor **405** and an example power controller **410**, which may be similar or identical to the respective monitoring processor **305** and power controller **310** of FIG. **3**. The home unit audience measurement meter **115**A of FIG. **4** also includes an example meter interrogator **415** to interrogate site units, such as the site unit audience measurement meters **115**B-C, to obtain their stored audience measurement data. Additionally or alternatively, in some examples, the meter interrogator **415** is configured to query a state monitor, such as one of the state monitors **120**B-C or **200**, associated with the site unit to obtain information regarding the media presentation device being monitored by the site unit before querying the site unit for its audience measurement data.

Assume, for example and without loss of generality, that a current interrogation/measurement interval has expired and the home unit audience measurement meter **115**A is to interrogate the site unit audience measurement meter **115**B. In some examples, prior to interrogating the meter **115**B, the meter interrogator **415** of the home unit audience measurement meter **115**A sends a state query to the state monitor **120**B to obtain information regarding the activation state of the media presentation device **110**B during the current interrogation/measurement interval. If the state monitor **120**B replies with an indication that the media presentation device **110**B has been inactive during the entire interrogation/measurement interval, the meter interrogator **415** can determine that no audience measurement data is available at the site unit audience measurement meter **115**B and, thus, skip interrogating the meter **115**B for current interrogation/measurement interval. As such, the meter interrogator **415** can avoid causing the site unit audience measurement meter **115**B to wake-up and consume additional power unnecessarily. However, if the state monitor **120**B replies with an indication that the media presentation device **110**B has been active during at least part of the current interrogation/measurement interval, the meter interrogator **415** can determine that audience measurement data may be available at the site unit audience measurement meter **115**B and, thus, interrogate the meter **115**B to obtain its audience measurement data.

A block diagram of an example implementation of the data processing facility **135** of FIG. **1** is illustrated in FIG. **5**. The example data processing facility **135** of FIG. **5** includes an example data receiver **505** to receive audience measurement data from one or more home units, such as the home unit audience measurement meter **115**A. Additionally, in some examples, the data receiver **505** receives presentation device state data representing the activation state(s) of media presentation device(s) associated with the received audience measurement data. In the illustrated example of FIG. **5**, the data processing facility **135** also includes an example data processor **510** to perform any type of post-processing on the audience measurement data obtained by the data receiver **505**. Examples of post-processing that can be performed by the data processor **510** includes, but is not limited to, determining ratings information for content presented at the monitored sites **105**A-C, performing commercial advertisement verification for commercials included in the media content presented at the monitored sites **105**A-C, etc.

Additionally, the example data processing facility **135** of FIG. **5** includes an example meter fault determiner **515** to determine whether to fault (e.g., invalidate) audience measurement data obtained by the data receiver **505** and corresponding to a particular audience measurement meter. Prior techniques for determining whether to fault audience measurement data generally fault the data for an entire measurement interval if the audience measurement data indicates that the audience measurement meter experienced a power outage or other outage (e.g., such as a communication outage) during any portion of the measurement interval. In contrast to such prior techniques, the fault determiner **515** can use the presentation device state data obtained by the data receiver **505** to determine whether audience measurement data that indicates that an outage has occurred is to be faulted or can remain valid even though the outage occurred.

For example, assume without loss of generality that the data receiver **505** receives audience measurement data associated with the audience measurement meter **115**B, and which indicates that the meter **115**B experienced outage(s) during one or more outage intervals (e.g., as indicated by gap(s) in the audience measurement data). Such outage(s) can correspond to power outage(s), communication outage(s) corresponding to a disruption in communication between the site unit audience measurement meter **115**B and the home unit audience measurement meter **115**A, other outage(s), or combination(s) thereof. The data receiver **505** also receives presentation device state data associated with the state monitor **120**B that indicates occurrences of activation state changes and the resulting activation states (e.g., active/on, inactive/off, etc.) of the monitored media presentation device **110**B, as well as the initiation time of each activation state change and the duration for each resulting monitored activation state. For example, in the case of a communication outage between the site unit audience measurement meter **115**B and the home unit audience measurement meter **115**A, the state monitor **120**B may still be able to report its presentation device state data to the home unit audience measurement meter **115**A via a different communication link/network. If the fault determiner **515** determines that any time interval over which the presentation device state data indicates the media presentation device **110**B was in an active state overlaps with any outage interval indicated by the audience measurement data, the fault determiner **515** faults the audience measurement data because the meter **115**B was unable to monitor the media presentation device **110**B for at least some of the time when the latter was active. However, if the fault determiner **515** determines that no time interval(s) over which the presentation device state data indicates the media presentation device **110**B was in an active state overlaps with any outage interval indicated by the audience measurement data, then the fault determiner **515** can decide to not fault the audience measurement data because no outage prevented the meter **115**B from monitoring the media presentation device **110**B while the latter was active. Furthermore, in some examples, if the fault determiner **515** detects that a particular audience measurement meter is experiencing outages over an extended period of time (or any appropriate interval of time), the fault determiner **515** can cause appropriate repair person-

nel to be dispatched to the affected monitored site to diagnose and repair the cause of the outage.

While example manners of implementing the audience measurement meters **115**A-C and **300**, the state monitors **120**A-C and **200**, and the data processing facility **135** have been illustrated in FIGS. **2-5**, one or more of the elements, processes and/or devices illustrated in FIGS. **2-5** may be combined, divided, re-arranged, omitted, eliminated and/or implemented in any other way. Further, one or more of the example audience measurement meters **115**A-C and/or **300**, the example state monitors **120**A-C and/or **200**, the example data processing facility **135**, the example presentation device state monitor **205**, the example meter power manager **230**, the example state logger **235**, the example RTC **240**, the example meter state reporter **255**, the example monitoring processors **305** and/or **405**, the example power controllers **310** and/or **410**, the example meter interrogator **415**, the example data receiver **505**, the example data processor **510** and/or the example meter fault determiner **515** of FIGS. **2-5** may be implemented by hardware, software, firmware and/or any combination of hardware, software and/or firmware. Thus, for example, any of the example audience measurement meters **115**A-C and/or **300**, the example state monitors **120**A-C and/or **200**, the example data processing facility **135**, the example presentation device state monitor **205**, the example meter power manager **230**, the example state logger **235**, the example RTC **240**, the example meter state reporter **255**, the example monitoring processors **305** and/or **405**, the example power controllers **310** and/or **410**, the example meter interrogator **415**, the example data receiver **505**, the example data processor **510** and/or the example meter fault determiner **515** could be implemented by one or more circuit(s), programmable processor(s), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)) and/or field programmable logic device(s) (FPLD(s)), etc. When any of the appended apparatus claims are read to cover a purely software and/or firmware implementation, at least one of the example audience measurement meters **115**A-C and/or **300**, the example state monitors **120**A-C and/or **200**, the example data processing facility **135**, the example presentation device state monitor **205**, the example meter power manager **230**, the example state logger **235**, the example RTC **240**, the example meter state reporter **255**, the example monitoring processors **305** and/or **405**, the example power controllers **310** and/or **410**, the example meter interrogator **415**, the example data receiver **505**, the example data processor **510** and/or the example meter fault determiner **515** are hereby expressly defined to include a tangible computer readable medium such as a memory, digital versatile disk (DVD), compact disk (CD), etc., storing such software and/or firmware. Further still, the example audience measurement meters **115**A-C and/or **300**, the example state monitors **120**A-C and/or **200**, the example data processing facility **135** of FIGS. **2-5** may include one or more elements, processes and/or devices in addition to, or instead of, those illustrated in FIGS. **2-5**, and/or may include more than one of any or all of the illustrated elements, processes and devices.

Flowcharts representative of example machine readable instructions that may be executed to implement one or more of the example audience measurement meters **115**A-C and/or **300**, the example state monitors **120**A-C and/or **200**, the example data processing facility **135**, the example presentation device state monitor **205**, the example meter power manager **230**, the example state logger **235**, the example RTC **240**, the example meter state reporter **255**, the example monitoring processors **305** and/or **405**, the example power controllers **310** and/or **410**, the example meter interrogator **415**, the example data receiver **505**, the example data processor **510** and/or the example meter fault determiner **515** are shown in FIGS. **6-11**. In these examples, the machine readable instructions represented by each flowchart may comprise one or more programs for execution by a processor, such as the processor **1212** shown in the example processing system **1200** discussed below in connection with FIG. **12**. Alternatively, the entire program or programs and/or portions thereof implementing one or more of the processes represented by the flowcharts of FIGS. **6-11** could be executed by a device other than the processor **1212** (e.g., such as a controller and/or any other suitable device) and/or embodied in firmware or dedicated hardware (e.g., implemented by an ASIC, a PLD, an FPLD, discrete logic, etc.). Also, one or more of the machine readable instructions represented by the flowchart of FIGS. **6-11** may be implemented manually. Further, although the example machine readable instructions are described with reference to the flowcharts illustrated in FIGS. **6-11**, many other techniques for implementing the example methods and apparatus described herein may alternatively be used. For example, with reference to the flowcharts illustrated in FIGS. **6-11**, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, combined and/or subdivided into multiple blocks.

As mentioned above, the example processes of FIGS. **6-11** may be implemented using coded instructions (e.g., computer readable instructions) stored on a tangible computer readable medium such as a hard disk drive, a flash memory, a read-only memory (ROM), a CD, a DVD, a cache, a random-access memory (RAM) and/or any other storage media in which information is stored for any duration (e.g., for extended time periods, permanently, brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term tangible computer readable medium is expressly defined to include any type of computer readable storage and to exclude propagating signals. Additionally or alternatively, the example processes of FIGS. **6-11** may be implemented using coded instructions (e.g., computer readable instructions) stored on a non-transitory computer readable medium, such as a flash memory, a ROM, a CD, a DVD, a cache, a random-access memory (RAM) and/or any other storage media in which information is stored for any duration (e.g., for extended time periods, permanently, brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable medium and to exclude propagating signals. Also, as used herein, the terms “computer readable” and “machine readable” are considered equivalent unless indicated otherwise.

Example machine readable instructions **600** that may be executed to implement power management processing in one or more of the state monitors **120**A-C and/or **200** of FIGS. **1-2** are represented by the flowchart shown in FIG. **6**. For convenience, and without loss of generality, the machine readable instructions **600** are described in the context of execution by the state monitor **200** of FIG. **2** to implement the state monitor **120**A of FIG. **1**. As such, in this example, the state monitor **200** is performing the role of the state monitor **120**A and, thus, is associated with the media presentation device **110**A and the audience measurement meter **115**A. With reference to the preceding figures, the machine readable instructions **600** of FIG. **6** begin execution at block **605** at which the presentation device state monitor **205** of the state monitor **200** monitors and detects an activation state of the media presentation device **110**A. If the media presentation device **110**A is determined to be active (block **610**), then at block **615** the meter

power manager **230** of the state monitor **200** controls activation of the audience measurement meter **115**A by sending an appropriate activation signal (e.g., wake-up signal) to cause the audience measurement meter **115**A to transition to an enabled state (e.g., state S0 of Table 1). However, if the media presentation device **110**A is determined to be inactive (block **610**), then at block **620** the meter power manager **230** controls activation of the audience measurement meter **115**A by sending an appropriate sleep signal to cause the audience measurement meter **115**A to transition to a sleep state (e.g., state S3 of Table 1). Processing then returns to block **605** to enable the presentation device state monitor **205** to continue monitoring the activation state of the media presentation device **110**A.

Example machine readable instructions **700** that may be executed to implement power control processing in one or more of the audience measurement meters **115**A-C and/or **300** of FIGS. **1**, **3** and **4** are represented by the flowchart shown in FIG. **7**. For convenience, and without loss of generality, the machine readable instructions **700** are described in the context of execution by the audience measurement meter **115**A of FIGS. **1** and **4**. With reference to the preceding figures, the machine readable instructions **700** of FIG. **7** begin execution at block **705** at which power controller **410** of the audience measurement meter **115**A receives a power control signal from the state monitor **120**A. If the power control signal corresponds to an activation (wake-up) signal (block **710**), then at block **715** the power controller **410** sets the audience measurement meter **115**A (e.g., by appropriate configuration of its monitoring processor **405**) to an enabled state (e.g., state S0 of Table 1). If, however, the power control signal corresponds to a sleep signal (block **710**), then at block **720** the power controller **410** sets the audience measurement meter **115**A (e.g., by appropriate configuration of its monitoring processor **405**) to a sleep state (e.g., state S3 of Table 1). Processing then returns to block **705** to enable the power controller **410** to continue performing power control for the audience measurement meter **115**A.

Example machine readable instructions **800** that may be executed to implement state reporting in one or more of the state monitors **120**A-C and/or **200** of FIGS. **1**-**2** are represented by the flowchart shown in FIG. **8**. For convenience, and without loss of generality, the machine readable instructions **800** are described in the context of execution by the state monitor **200** of FIG. **2** to implement the state monitor **120**B of FIG. **1**. As such, in this example, the state monitor **200** is performing the role of the state monitor **120**B and, thus, is associated with the media presentation device **110**B and the audience measurement meter **115**B. With reference to the preceding figures, the machine readable instructions **800** of FIG. **8** begin execution at block **805** at which the presentation device state monitor **205** and the state logger **235** of the state monitor **200** monitor and log presentation device state data representing the activation state of the media presentation device **110**B. In some examples, at block **810** the state logger **235** also logs power outage interval(s) monitored for the power source **140**B powering the state monitor **200**.

At block **815**, the meter state reporter **255** determines whether a state query has been received from the home unit audience measurement meter **115**A. If a state query has been received (block **815**), at block **820** the meter state reporter **255** processes the presentation device state data logged at block **805** to determine whether the media presentation device **110**B was inactive during the current interrogation/measurement interval (e.g., corresponding to a current interval of time starting from the last state query). If the media presentation device **110**B was inactive during this entire interval (block **825**), then at block **830** the meter state reporter **255** replies to the state query with an indication that the media presentation device **110**B being monitored by the site unit audience measurement meter **115**B was inactive during the entire interrogation/measurement interval and, thus, the site unit audience measurement meter **115**B has no audience measurement data to report. In this case, the home unit audience measurement meter **115**A can skip interrogation of the site unit audience measurement meter **115**B for the current interrogation/measurement interval. However, if the media presentation device **110**B was active during at least part of the interrogation/measurement interval (block **825**), then at block **835** the meter state reporter **255** replies to the state query with an indication that the media presentation device **110**B was active during the interrogation/measurement interval and, thus, the site unit audience measurement meter **115**B may have audience measurement data to report. In this case, the home unit audience measurement meter **115**A proceeds with interrogation of the site unit audience measurement meter **115**B to obtain its audience measurement data for the current interrogation/measurement interval.

Example machine readable instructions **900** that may be executed to implement meter interrogation processing in the home unit audience measurement meter **115**A of FIGS. **1** and **4** are represented by the flowchart shown in FIG. **9**. For convenience, and without loss of generality, the machine readable instructions **900** are described in the context of execution by the home unit audience measurement meter **115**A to interrogate the site unit audience measurement meter **115**B of FIG. **1**. With reference to the preceding figures, the machine readable instructions **900** of FIG. **9** begin execution at block **905** at which the meter interrogator **415** of the home unit audience measurement meter **115**A queries the state monitor **120**B associated with the site unit audience measurement meter **115**B to determine whether the media presentation device **110**B was active during the current interrogation/measurement interval and, thus, to determine whether the site unit audience measurement meter **115**B has any audience measurement data to report. At block **910** the meter interrogator **415** evaluates the response received from the state monitor **120**B. If the response indicates that the media presentation device **110**B was inactive during the entire interrogation/measurement interval and, thus, no audience measurement data is available (block **910**), then at block **915** the meter interrogator **415** skips (e.g., does not perform) waking-up and interrogation of the site unit audience measurement meter **115**B. In some example, processing proceeds to block **920** at which the meter interrogator **415** further sends a sleep signal to the site unit audience measurement meter **115**B to enable the meter **115**B to enter a sleep state (e.g., state S3 of Table 1) if, for example, the meter **115**B has not otherwise been enabled to perform other processing.

However, if the response indicates that the media presentation device **110**B was active during the interrogation/measurement interval and, thus, audience measurement data may be available (block **910**), then at block **925** the meter interrogator **415** sends an appropriate activation signal (e.g., wake-up signal) to cause the site unit audience measurement meter **115**B to transition to an enabled state (e.g., state S0 of Table 1). At block **930**, the meter interrogator **415** then queries the site unit audience measurement meter **115**B to obtain any audience measurement data to be reported. After the audience measurement data is received from the site unit audience measurement meter **115**B (block **935**), at block **920** the meter interrogator **415** sends a sleep signal to the site unit audience measurement meter **115**B to enable the meter **115**B to enter a

sleep state (e.g., state S3 of Table 1) if the meter **115**B has not otherwise been enabled to perform other processing.

Example machine readable instructions **1000** that may be executed to implement data reporting in the home unit audience measurement meter **115**A of FIGS. **1** and **4** are represented by the flowchart shown in FIG. **10**. With reference to the preceding figures, the machine readable instructions **1000** of FIG. **10** begin execution at block **1005** at which the meter interrogator **415** of the home unit audience measurement meter **115**A queries the state monitors **120**A, **120**B and **120**C for presentation device state data representing the activation state history for the respective media presentation devices **110**A, **110**B and **110**C being monitored by the respective site unit audience measurement meters **115**A, **115**B and **115**C. At block **1010**, the home unit audience measurement meter **115**A interrogates the site unit audience measurement meters **115**B and **115**C to obtain their respective audience measurement data, as appropriate (e.g., using the example machine readable instructions **900** of FIG. **9**). At block **1015**, the home unit audience measurement meter **115**A reports the presentation device state data obtained from the state monitors **120**A-C and the audience measurement data obtained from the site unit audience measurement meters **115**B-C, as well as the audience measurement data determined by the home unit audience measurement meter **115**A itself, to the data processing facility **135**. As noted above, the audience measurement data reported at block **1015** includes power outage and/or other outage information for the respective audience measurement meters **115**A-C (e.g., in the form of gaps in the audience measurement data for the respective meters **115**A-C).

Example machine readable instructions **1100** that may be executed to implement fault determination processing in the data processing facility **135** of FIGS. **1** and **5** are represented by the flowchart shown in FIG. **11**. With reference to the preceding figures, the machine readable instructions **1100** of FIG. **11** begin execution at block **1105** at which the data receiver **505** of the data processing facility **135** receives respective audience measurement data obtained from the audience measurement meters **115**A-C, and also respective presentation device state data obtained from the state monitors **120**A-C. For convenience, and without loss of generality, the remainder of the machine readable instructions **1100** are described from the perspective of processing the audience measurement data obtained from the audience measurement meter **115**A and processing the presentation device state data obtained from the state monitor **120**A. As such, at block **1110** the meter fault determiner **515** of the data processing facility **135** determines whether the audience measurement data obtained from the audience measurement meter **115**A indicates that the meter **115**A experienced an outage (e.g., corresponding to a gap in the measurement data). If no outage occurred (block **1110**), then the meter fault determiner **515** determines that the audience measurement data is valid and, at block **1115**, the data processor **510** of the data processing facility **135** performs any appropriate post-processing on the audience measurement data obtained from the audience measurement meter **115**A.

However, if the audience measurement data indicates that an outage occurred (block **1110**), then at block **1120** the meter fault determiner **515** determines whether any outage interval determined from the audience measurement data overlaps (at least partially) with any time interval over which the presentation device state data obtained from the state monitor **120**A indicates that the media presentation device **110**A was active. If there is any overlap of these time intervals (block **1120**), then at block **1125** the meter fault determiner **515** faults the audience measurement data obtained from the audience measurement meter **115**A. If, however, there is no overlap between any outage time intervals determined from the audience measurement data and the active device time intervals determined from the presentation device state data (block **1120**), then at block **1130** the meter fault determiner **515** does not fault the audience measurement data obtained from the audience measurement meter **115**A. In this case, the meter fault determiner **515** determines that the audience measurement data is valid, and processing proceeds to block **1115** at which the data processor **510** performs any appropriate post-processing on the audience measurement data.

FIG. **12** is a block diagram of an example processing system **1200** capable of implementing the apparatus and methods disclosed herein. The processing system **1200** can be, for example, a server, a personal computer, a personal digital assistant (PDA), an Internet appliance, a DVD player, a CD player, a digital video recorder, a personal video recorder, a set top box, or any other type of computing device.

The system **1200** of the instant example includes a processor **1212** such as a general purpose programmable processor. The processor **1212** includes a local memory **1214**, and executes coded instructions **1216** present in the local memory **1214** and/or in another memory device. The processor **1212** may execute, among other things, the machine readable instructions represented in FIGS. **6**-**11**. The processor **1212** may be any type of processing unit, such as one or more Intel® microprocessors from the Atom™ family, the Pentium® family, the Itanium® family and/or the XScale® family, one or more microcontrollers from the ARM® and/or PIC® families of microcontrollers, etc. Of course, other processors from other families are also appropriate.

The processor **1212** is in communication with a main memory including a volatile memory **1218** and a non-volatile memory **1220** via a bus **1222**. The volatile memory **1218** may be implemented by Static Random Access Memory (SRAM), Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), RAMBUS Dynamic Random Access Memory (RDRAM) and/or any other type of random access memory device. The non-volatile memory **1220** may be implemented by flash memory and/or any other desired type of memory device. Access to the main memory **1218**, **1220** is typically controlled by a memory controller (not shown).

The processing system **1200** also includes an interface circuit **1224**. The interface circuit **1224** may be implemented by any type of interface standard, such as an Ethernet interface, a universal serial bus (USB), and/or a third generation input/output (3GIO) interface.

One or more input devices **1226** are connected to the interface circuit **1224**. The input device(s) **1226** permit a user to enter data and commands into the processor **1212**. The input device(s) can be implemented by, for example, a keyboard, a mouse, a touchscreen, a track-pad, a trackball, an isopoint and/or a voice recognition system.

One or more output devices **1228** are also connected to the interface circuit **1224**. The output devices **1228** can be implemented, for example, by display devices (e.g., a liquid crystal display, a cathode ray tube display (CRT)), by a printer and/or by speakers. The interface circuit **1224**, thus, typically includes a graphics driver card.

The interface circuit **1224** also includes a communication device such as a modem or network interface card to facilitate exchange of data with external computers via a network (e.g., an Ethernet connection, a digital subscriber line (DSL), a telephone line, coaxial cable, a cellular telephone system, etc.).

The processing system 1200 also includes one or more mass storage devices 1230 for storing machine readable instructions and data. Examples of such mass storage devices 1230 include floppy disk drives, hard drive disks, compact disk drives and digital versatile disk (DVD) drives. In some examples, the mass storage device 1230 may store the presentation device state data logged by the example state logger 235 of the example state monitor 220. Additionally or alternatively, in some examples the volatile memory 1218 may store the presentation device state data logged by the example state logger 235.

The coded instructions 1232 of FIGS. 6-11 may be stored in the mass storage device 1230, in the volatile memory 1218, in the non-volatile memory 1220, in the local memory 1214 and/or on a removable storage medium, such as a CD or DVD 1232.

As an alternative to implementing the methods and/or apparatus described herein in a system such as the processing system of FIG. 12, the methods and or apparatus described herein may be embedded in a structure such as a processor and/or an ASIC (application specific integrated circuit).

Finally, although certain example methods, apparatus and articles of manufacture have been described herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents.

What is claimed is:

1. A method comprising:

monitoring, using a processor, an activation state of a media presentation device; and

controlling, using the processor, activation of an audience measurement meter different from the media presentation device based on the monitored activation state of the media presentation device, the audience measurement meter to monitor the media presentation device when the activation state is an active state, the controlling comprising:

in response to determining that the media presentation device has been active during at least a portion of a time interval prior to a first time, (1) sending a wake-up signal to activate the audience measurement meter and (2) interrogating the audience measurement meter to obtain audience measurement data associated with the time interval prior to the first time; and

in response to determining that the media presentation device has been inactive over the time interval prior to the first time, determining that interrogation of the audience measurement meter to obtain audience measurement data associated with the time interval prior to the first time is to be skipped.

2. A method as defined in claim 1 wherein monitoring the activation state of the media presentation device comprises:

measuring power consumption of the media presentation device;

determining that the activation state is the active state when the measured power consumption exhibits a positive slope change; and

determining that the activation state is an inactive state when the measured power consumption exhibits a negative slope change.

3. A method as defined in claim 1 wherein monitoring the activation state of the media presentation device comprises:

monitoring an audio output of the media presentation device;

determining that the activation state is the active state when an audio signal is detected at the monitored audio output; and

determining that the activation state is an inactive state when no audio signal is detected at the monitored audio output.

4. A method as defined in claim 1 wherein controlling the activation of the audience measurement meter further comprises:

sending the wake-up signal to the audience measurement meter in response to determining that the media presentation device is in the active state; and

sending a sleep signal to the audience measurement meter in response to determining that the media presentation device is in an inactive state.

5. A method as defined in claim 4 further comprising:

setting the audience measurement meter to an enabled state in response to receiving the wake-up signal, the wake-up signal being communicated via at least one of a wired local area network (LAN), a wireless LAN, a universal serial bus (USB) or an input/output (I/O) pin; and

setting the audience measurement meter to a sleep state in response to receiving the sleep signal, the sleep signal being communicated via at least one of the wired LAN, the wireless LAN, the USB or the I/O pin.

6. A method as defined in claim 1 further comprising:

sending a sleep signal to the audience measurement meter after the audience measurement data is obtained.

7. A method comprising:

measuring, using a processor, power consumption of a media presentation device;

determining, using the processor, that an activation state of the media presentation device is an active state when the measured power consumption is greater than a first threshold;

determining, using the processor, that the activation state is an inactive state when the measured power consumption is less than a second threshold different from the first threshold; and

controlling, using the processor, activation of an audience measurement meter based on the monitored activation state of the media presentation device, the audience measurement meter to monitor the media presentation device when the activation state is the active state.

8. A tangible computer readable medium comprising machine readable instructions which, when executed, cause a machine to at least:

monitor an activation state of a media presentation device;

control activation of an audience measurement meter different from the media presentation device based on the monitored activation state of the media presentation device, the audience measurement meter to monitor the media presentation device when the activation state is an active state;

in response to the media presentation device having been active during at least a portion of a time interval prior to a first time, (1) send a wake-up signal to activate the audience measurement meter and (2) interrogate the audience measurement meter to obtain audience measurement data associated with the time interval prior to the first time; and

in response to the media presentation device having been inactive over the time interval prior to the first time, determine that interrogation of the audience measurement meter to obtain audience measurement data associated with the time interval prior to the first time is to be skipped.

9. A tangible computer readable medium as defined in claim **8** wherein to monitor the activation state of the media presentation device, the machine readable instructions, when executed, further cause the machine to:

measure power consumption of the media presentation device;

determine that the activation state is the active state when the measured power consumption is greater than a first threshold; and

determine that the activation state is an inactive state when the measured power consumption is less than at least one of the first threshold or a second threshold.

10. A tangible computer readable medium as defined in claim **8** wherein to monitor the activation state of the media presentation device, the machine readable instructions, when executed, further cause the machine to:

monitor an audio output of the media presentation device;

determine that the activation state is the active state when an audio signal is detected at the monitored audio output; and

determine that the activation state is an inactive state when no audio signal is detected at the monitored audio output.

11. A tangible computer readable medium as defined in claim **8** wherein to control the activation of the audience measurement meter, the machine readable instructions, when executed, further cause the machine to:

send the wake-up signal to the audience measurement meter in response to determining that the media presentation device is in the active state; and

send a sleep signal to the audience measurement meter in response to determining that the media presentation device is in an inactive state.

12. A tangible computer readable medium as defined in claim **11** wherein the machine readable instructions, when executed, further cause the machine to:

set the audience measurement meter to an enabled state in response to receiving the wake-up signal, the wake-up signal being communicated via at least one of a wired local area network (LAN), a wireless LAN, a universal serial bus (USB) or an input/output (I/O) pin; and

set the audience measurement meter to a sleep state in response to receiving the sleep signal, the sleep signal being communicated via at least one of the wired LAN, the wireless LAN, the USB or the I/O pin.

13. A tangible computer readable medium as defined in claim **8** wherein the machine readable instructions, when executed, further cause the machine to:

determine whether the media presentation device has been inactive over the time interval prior to the first time.

14. A tangible computer readable medium as defined in claim **8** wherein the machine readable instructions, when executed, further cause the machine to:

send a sleep signal to the audience measurement meter after the audience measurement data is obtained.

15. An apparatus comprising:

a state monitor to monitor an activation state of a media presentation device; and

a processor to:

control activation of an audience measurement meter different from the media presentation device based on the monitored activation state of the media presentation device, the audience measurement meter to monitor the media presentation device when the activation state is an active state;

in response to the media presentation device having been active during at least a portion of a time interval prior to a first time, (1) send a wake-up signal to activate the audience measurement meter and (2) interrogate the audience measurement meter to obtain audience measurement data associated with the time interval prior to the first time; and

in response to the media presentation device having been inactive over the time interval prior to the first time, determine that interrogation of the audience measurement meter to obtain audience measurement data associated with the time interval prior to the first time is to be skipped.

16. An apparatus as defined in claim **15** wherein to monitor the activation state of the media presentation device, the state monitor is to:

measure power consumption of the media presentation device;

determine that the activation state is the active state when the measured power consumption is greater than a first threshold; and

determine that the activation state is an inactive state when the measured power consumption is less than at least one of the first threshold or a second threshold.

17. An apparatus as defined in claim **15** wherein to monitor the activation state of the media presentation device, the state monitor is to:

monitor an audio output of the media presentation device;

determine that the activation state is the active state when an audio signal is detected at the monitored audio output; and

determine that the activation state is an inactive state when no audio signal is detected at the monitored audio output.

18. An apparatus as defined in claim **15** wherein to control activation of the audience measurement meter, the processor is to:

send the wake-up signal to the audience measurement meter in response to determining that the media presentation device is in an active state; and

send a sleep signal to the audience measurement meter in response to determining that the media presentation device is in an inactive state.

19. An apparatus as defined in claim **18** wherein the processor is further to:

set the audience measurement meter to an enabled state in response to receiving the wake-up signal, the wake-up signal being communicated via at least one of a wired local area network (LAN), a wireless LAN, a universal serial bus (USB) or an input/output (I/O) pin; and

set the audience measurement meter to a sleep state in response to receiving the sleep signal, the sleep signal being communicated via at least one of the wired LAN, the wireless LAN, the USB or the I/O pin.

20. An apparatus as defined in claim **15** wherein the processor is further to:

determine whether the media presentation device has been inactive over the time interval prior to the first time.

21. An apparatus as defined in claim **15** wherein the processor is further to:

send a sleep signal to the audience measurement meter after the audience measurement data is obtained.

* * * * *

EXHIBIT B

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

THE NIELSEN COMPANY (US), LLC, Plaintiff, v. HYPHAMETRICS, INC., Defendant.	)))))))))))))	C.A. No. _________ **JURY TRIAL DEMANDED**

DECLARATION OF VIRGINIA LEE

I, Virginia Lee, declare as follows:

INTRODUCTION AND ENGAGEMENT

1. I have been retained on behalf of The Nielsen Company (US), LLC ("Nielsen") to offer technical opinions relating to U.S. Patent No. 8,924,994 ("the '994 patent").

2. I have no financial interest in either party to, or in the outcome of, the above-styled proceeding. I am being compensated for my work as an expert on an hourly basis at my standard consulting rate. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

PERSON OF ORDINARY SKILL IN THE ART

3. In my opinion, a person of ordinary skill in the art ("POSA") in the field of the patents-in-suit would have a working knowledge of the software and/or hardware of audience measurement and tracking systems. The POSA would have gained this knowledge through an undergraduate degree in an applicable engineering field (for example, electrical or computer

engineering or computer science) and at least five years of work experience in relevant fields.

MY EXPERTISE

4. My CV, attached to this declaration as Exhibit A, demonstrates my expertise in the field of the patents-in-suit. In particular, I have a bachelor's degree in Engineering Science, which is a multi-discipline, five-year undergraduate degree encompassing Computer Science, Electrical Engineering, and Mathematics. I also have over a decade of relevant work experience in the field. During that time, I led and took part in multiple design projects for enhancements to TV audience measurement systems, TV program collection and verification systems, and TV/Online advertising measurement systems.

INFORMATION CONSIDERED

5. I have reviewed the '994 patent as well as other materials referenced in Appendix A to this declaration. Counsel has informed me that I should consider these materials through the lens of one skilled in the art of the field of the patents-in-suit at the time of the priority date of the '994 patent, and I have done so. I have assumed the priority date of the '994 patent is May 31, 2011, the filing date of the patent. In this declaration, I use the term "prior art" to refer to what was known and/or done before the priority date of the applicable patent.

6. My analyses are based on my education and work experience, in addition to my investigation and study of materials listed in Appendix A.

THE '994 PATENT

7. Claim 7 of the '994 patent recites a method that includes measuring the power consumption of a media presentation device (such as a television); determining that the media presentation device is in an active state (*i.e.*, it is "on") when the measured power consumption is greater than a first threshold; determining that the media presentation device is in an inactive

state (*i.e.*, it is “off”) when the measured power consumption is less than a second threshold different from the first threshold; and controlling activation (*i.e.*, switching on or off) of an audience measurement meter based on the activation state of the media presentation device, the audience measurement meter to monitor the media presentation device when the activation state is the active state. (‘994 patent, Claim 7.)

8. Determining that the media presentation device is in an active state (*i.e.*, it is “on”) when the measured power consumption is greater than a first threshold and determining that the media presentation device is in an inactive state (*i.e.*, it is “off”) when the measured power consumption is less than a second threshold different from the first threshold (“the Two Threshold Element”) is inventive and novel. Furthermore, controlling activation of an audience measurement meter based on a determination of the activation state of the media presentation device by using two thresholds with regard to power consumption, where the audience measurement meter monitors the media presentation device when the activation state is the active state (“the Activation Control Element”) is inventive and novel. As of the priority date of the ‘994 patent, neither the Two Threshold Element nor the Activation Control Element were well-understood, routine, or conventional.

9. In practice, for example, the Two Threshold Element provides an approach to determining whether a viewer’s television set is on or off. (*See, e.g.*, ‘994 patent, 2:19-21; 4:15-16; 8:17-24.) In particular, this approach uses a first power consumption threshold to determine that the television is on, and a second power consumption threshold to determine that the television is off. (*Id.*, 8:4-12.) Power consumption is measured in watts (W), so for example, if the first power consumption threshold is 60W, and the second power consumption threshold is 10W, then the Two Threshold Element approach determines that the television is on if its power

consumption exceeds 60W, and that the television is off if its power consumption is less than 10W. If the power consumption is between 10W and 60W, no determination is made – *i.e.*, if the television was previously determined to be on, there will be no change to that determination. Similarly, if the television was previously determined to be off, there will be no change to that determination.

10. The Two Threshold Element was not known or done in the prior art. Before the priority date of the ‘994 patent, determining the activation state of the media presentation device by measuring power consumption was not done. (*See, e.g.., id.*, 3:2-9.) Monitoring the activation state of the media presentation device at all was rare, but when it was done, other methods were used. For example, one prior art approach was to monitor the audio output of a television to determine whether it was on or off.

11. The Two Threshold Element allows the accurate determination of the activation state of the media device by measuring power consumption. In particular, using two thresholds results in an effect known as hysteresis, which is an advantage for the approach of measuring power consumption. Hysteresis is an effect in which the state of a system depends not only on current inputs, but also on prior inputs and state, and in which rapid measured changes in state are reduced or prevented. This can be best explained with an example. If a television has an average power consumption of 40W when in the on state, the power consumption most of the time will not be exactly 40W. Instead, the consumption will vary slightly; sometimes it will be above 40W, and sometimes it will be below 40W. Transitions from power consumption above 40W to power consumption below 40W, and vice versa, can be frequent and rapid. Thus, if a single threshold of 40W were used to determine whether the television is on or off, a false determination that the television was periodically turning on and off would result. The Two

Threshold Element provides a great improvement. Specifically, it uses a hysteresis effect in which the determined state of the media presentation device changes only if the variation in power consumption is significant enough to evidence a true change in the on/off state of the device. If, for example, thresholds of 40W and 10W are used, then the television will be determined to be on if the power consumption is above 40W and off if the power consumption is below 10W. If the power consumption is between 10W and 40W, the television's state will be determined to remain the same as the last determined state.

12. Measuring power consumption is an improvement over prior art methods such as monitoring audio output. In particular, the audio output approach was inaccurate because sound levels of media content vary widely, and thus, a quiet scene in a program often caused the incorrect determination that the television was in the off state. Additional inaccuracy of the audio output approach could be caused by spillover audio from other rooms or audio echoing off walls.

13. In practice, for example, the Activation Control Element approach is to control an audience measurement device (*i.e.*, a device that monitors who is in the area of the television when particular programs are playing) according to whether the television is on or off, based on the use of two thresholds to measure television power consumption. (*Id.*, 2:64-3:9.) The Activation Control Element was not known or done in the prior art. (*See id.*) The prior art's failure to use the approach of the Activation Control Element resulted in two major problems. First, it resulted in inefficient and wasteful use of energy. (*See id.*) And second, it resulted in the inaccuracy associated with monitoring the audience (*i.e.*, leaving the audience measurement device on) when the television was off. (*Id.*, 3:19-49.)

14. The Activation Control Element approach solved the above-mentioned prior art

problems regarding inaccuracy and power usage efficiency by keeping the audience measurement device active only when the television is actually on. (*See id.*, 2:64-3:49.)

15. The Activation Control Element provides one specific way (an improved way) to manage power usage and improve the accuracy of audience measurement.

16. Similarly, the Two Threshold Element provides one specific way to determine the activation state of a media presentation device. Other approaches, such as the audio output monitoring approach discussed above, can be used.

CONCLUSION

17. I declare under penalty of perjury that the foregoing statements are true and accurate to the best of my knowledge.

Dated: October 27, 2021

Virginia Lee

APPENDIX A

MATERIALS CONSIDERED

United States Patent No. 8,924,994

United States Patent No. 7,665,104

United States Patent No. 7,786,987

United States Patent No. 7,882,514

United States Patent No. 8,156,517

U.S. Patent Publication No. 2006/0212895

U.S. Patent Publication No. 2007/0011040

U.S. Patent Publication No. 2009/0070797

U.S. Patent Publication No. 2011/0126222

U.S. Patent Publication No. 2012/0159529

CA 2777579

JP 2010171606

EXHIBIT A

ecomp CONSULTANTS
INFORMATION TECHNOLOGY & PATENT LITIGATION
TELECOMMUNICATIONS ▪ INTERNET ▪ EFORENSICS
301 W Platt St, Suite 365, Tampa, FL 33606
vlee@ecompconsultants.com, (813) 334-6719,

Virginia Lee has extensive experience in engineering science with a concentration in computer engineering. Ms. Lee has been employed in various industries and as an independent consultant specializing in software product design, product management, and strategic consulting. Ms. Lee has provided consulting services in mobile application solutions, user interface and authentication methods, networked device monitoring and CRM/ERP systems for corporations such as: Nielsen Media, Verizon, United Airlines, ConEd, Dominion, Southwest Gas and Global Crossings. She holds degrees in Engineering and an MBA.

Ms. Lee has been a consulting and testifying expert for cases including patent litigation, trade secret and contract disputes for secure payment systems, cellular data technology and device monitoring.

Professional Experience:

2006 to Present — **Expert Consultant**
eComp Consultants ***Tampa, FL***

Provide consulting on design and development of software products and ecommerce technology. Provide technology consulting and expert support for telecommunications, internet, and ecommerce applications in the areas of:

- Patent portfolio evaluation, market valuation, and prior art analysis.
- Patent litigation for telecommunications, internet, gaming, and POS technology patents for validity/invalidity and infringement/non-infringement analysis.
- Software contract due diligence and functional analyses for disputes involving custom software, UI/website design, mobile technologies and ecommerce.
- Standards Team Lead: NIST Cyber Security Working Group for the SmartGrid

2011 to 2020 — **VP, Technology**
Nielsen

Technology Leader focused on delivery of strategic global initiatives for the CIO. Managed development and delivery teams across multiple business units, led the Global Cyber Security team and owned M&A Technology Integration.

- Led M&A Integration for technology and infrastructure teams for Due Diligence, Acquisition Integration and Divestitures. Portfolio included 12-15 active global efforts in various stages of progress and size
- Advised on secure design training for metering team to secure metering devices being deployed globally.
- Adviser to the Audit team for matters involving controls regulated by the Media Ratings Council (MRC)
- Led application development for solutions providing user experience Nielsen panel and TV, Broadcasting and Syndicated providers.
- Worked closely with Engineering and Operations teams to develop software solutions bridging data ingestion from devices to reporting output.

- Managed 35+ direct reports & 50+ contractors (onshore/offshore) in delivery of measurement solutions for TV, Online, and Advertising products.
- Platform owner for 10+ disparate systems serving multiple global business units, including Local and National TV measurement, advertising measurement, and consumer products measurement.

2006 to 2008 **Independent Consultant**

The Nielsen Company ***Oldsmar, FL***

High profile project included as part of enterprise-wide transformation and global convergence initiatives to develop web-based client services.

- Developed, championed and sold strategic business plan to support new opportunities in web-based solutions to TV measurement clients
- Developed prototypes for customer facing website and web-based functionality
- Led usability testing with clients and internal users for client website operations

United Illuminating ***New Haven, CT***

- Project Manager for Outage Management System (OMS) Interface phase of the Mobile Upgrade project. Managed five-person team and vendor representatives in development of requirements, use cases and integration specs for network device management.
- SME/Advisor for Mobility Upgrade project to provide feature and integration analysis, design and testing strategy for SAP and OMS interfaces.

Enspiria Solutions, Inc. ***Denver, CO***

Project Engineer for systems integration services between Data Collection Devices and CRM, Call Center, and SCADA systems; including requirements, design and testing.

ViryaNet, Inc. ***Southborough, MA***

Retained through 2006 as Account Manager for two major utility accounts. Included preparation and presentation of proposals for services and customer liaison.

2004 to 2006 **Solutions Architect/Account Management**

ViryaNet, Inc. ***Southborough, MA***

Provided consulting, pre-sales and account management support for ViryaNet's web-based Mobile Workforce Scheduling and Management System, Service Hub.

- Reviewed client environments to determine product fit to business requirements/embedded base, defined solution scope and designed product integration of web products into existing client environments.
- Designed and developed browser-based applications for wireless mobile platforms.

2002 to 2004 **Independent Consultant/Self Employed**

United Illuminating **New Haven, CT**

Provided consulting services specific to the integration and business processes associated with the SAP CRM, Mobile Workforce, Outage Management and EDI solutions.

- Reviewed SAP BluePrints, facilitated design sessions between client, SAP and Mobile Workforce vendor

- Developed detailed integration specifications between Mobile Workforce vendor and SAP workflows for Call Center staff
- Participated with the SAP team in performing detailed integration testing of SAP transactions, IDOCs, workflows, and call center user interface, etc.
- Developed detailed specifications for IBM's Websphere Data Interchange for the transformation of IDOCs from/to XML for Mobile Workforce Automation Project
- Project Manager for EDI project to meet State, DPUC and client requirements.

2000 to 2002 **Consultant**

Tanning Technology Corporation ***Denver, CO***

United Airlines

Lead on systems integration, web interface, rules design, testing methodology and application design for multi-phased website implementation for client booking engine, customer profiles, secure authentication and strategic campaign management.

Global Crossings/Global Center

Drove strategic design initiatives for incorporating ecommerce, network infrastructure monitoring and alerts, and change control processes to meet IPO requirements.

Rhythms – DSL provider

Lead on requirements for redesign of provisioning processes to integrate with Price Waterhouse CRM system and meet systems performance guidelines.

Tanning Technology

Product Manager for changing corporate business model to "productize" solutions in the Customer Marketing and Performance Technology areas. Focused on web-based support for industries such as Telecom/Utilities, Media, Logistics and Hospitality.

1996 to 2000 **Product Manager for Mobile Workforce Products**

Utility Partners Inc. ***Tampa, FL***

Provided direction for the development and support of standard product packages for special purpose components, such as: industry-specific and technology specific solutions:

- ISP solutions
- PDA/Wireless connectivity
- Multi-platform eCommerce and web-based technology

Provided consulting and professional services to clients for customization of mobile product functions for specific use, such as: enhanced outage, inspection and maintenance, eCommerce initiatives, GIS and ERP integration. Including Inspection and maintenance systems for monitoring and alerts of network attached devices.

Participated in cross-vendor consortium to design, prototype and present an end-to-end (ERP/CRM<->GIS) standard for call center, outage management and Mobile solutions.

1987 to 1996 **Product Manager / Sr. Advisory Systems Engineer –> Member Technical Staff**

GTE/Verizon ***Dallas, TX / Tampa, FL***

As Product Manager for Commercial Services, prepared full product plans, including:

- functional breakdowns, industry/competitive analysis, business models, distribution, pricing, packaging, staffing, marketing, and five year financial plans

As Systems Engineer, provided technology consulting, including:

- Platform workshops and presentations at International User Groups
- Specialized in call center systems for Customer Marketing Sales and Service, Network Infrastructure, Billing Systems integration, Distributed Systems Support
- Designed and developed EDI/B2B applications for Carrier Access Market and large scale custom CRM system for domestic Telco Call Centers
- Supported Disaster recovery (DRP) and outsourcing services for cellular clients
- Prototype development of human factors standards and workflow environments for GTE's commercial systems' platforms to support eCommerce initiatives and call center workflow for cross sell and up sell of telecom services
- Designed and published OO standards to all Domestic User Groups
- Evaluated data integration and deployment strategy in support of call center automation and CRM implementations
- Designed/developed intelligent agents for online customer access services and eCommerce, call center and CIS applications

1984 to 1987 **Software Engineer**

Paradyne Corporation ***Largo, FL***

Performed design, development, and testing activities for individual projects within telecommunications product group, specifically responsible for:

- TCP/IP communications integration with proprietary networking product
- OSI Session/Data Link protocol development for high-speed telecom product
- Session Error Recovery for OSI Session Layer for high-speed telecom product
- System generation software for high-speed telecommunications product
- Data emulation, capturing and user interface for channel-attached devices

1982 to 1984 **Software Application Designer**

OmniData Corporation ***Largo, FL***

Performed design, development, testing and operations activities for call center solutions to collect customer data for processing of non-profit marketing materials.

- Designed custom user interfaces for each customer
- Designed custom print formats for each customer
- Supported multiple data entry platforms including micro processors, PCs and early transportable platforms

Education/Certifications:

GSEC - Cyber Security Certification	2015	SANS Institute
Cyber Security: Critical Security Controls, Cloud and NW Security	2014	SANS Institute
MBA - Executive Master of Business Administration	1992	University of South Florida
BSES - Bachelor of Science in Engineering Science	1984	University of South Florida

Speaking/Publications

- Keynote Speaker: SWE Local Annual Meeting
- University of Miami - Annual Commercial Symposium - Technology Career Center
- WITI Special Event Speaker: Cyber Security Essentials - Unit 1
- Business/Technology Analysis & Integration Strategy for ERP System: Surname Electric (EBS)
- Published: NISTR 7628 Guidelines for Smart Grid Cyber Security - Standards Working Group
- Recurring Speaker for eCommerce: US TV Networks – Nielsen Program Guidelines Committee
- Recurring Speaker for emerging eCommerce strategy: Nielsen Strategy and Planning Committee
- Recurring Speaker: Mobile Product Standardization/Workflow: Utility Partners Int'l User's Group
- Recurring Speaker: Client/Server Technology in CRM: GTEDS International User's Conference
- Recurring Speaker: Workflow in CRM Solutions: GTEDS International User's Conference
- Business Process Analysis and Business Plan: Local TV Programming Ops - Nielsen Media
- Program Names Guidelines – eCommerce Rules: Local TV Programming Ops - Nielsen Media
- Integration design for Outage Management and Mobile Data Solutions: United Illuminating
- Training for Workforce Automation and Advanced Scheduling for Field Operations: UI
- User Interface Design and Training Materials for Mobile Workforce Pilot: So Cal Edison
- Interface Design, Testing, & Training for EDI to SAP Integration for Alternate Supplier Initiative: UI
- Integration Strategy for CRM Migration (SAP) and Mobile Data Solutions: United Illuminating
- Business Process and eCommerce Strategy for Customer Profile Management: United Airlines
- Strategy and Scoring Rules for Loyalty Programs Awards: United Airlines
- Operations and Performance Engineering Analysis for DSL Provisioning Operations: Rhythms
- Market Analysis for emerging business model in eCommerce Websites: Tanning Technology
- Product Plan for standard Mobile Data to CRM Solutions for Utility Operations: Utility Partners
- Business/Technology Analysis & Integration Strategy for Mobile Data: Montana Dakota Utilities
- Business/Technology Analysis & Integration Strategy for CRM & Mobile Operations: EPCOR
- Technology Analysis & Integration Strategy for Inspection & Maintenance: Stadtwerks Goettingen
- User Interface Design/Integration Strategy for CRM & Mobile Data Operations: Dominion Power
- User Interface Design/Integration Strategy for CRM & Mobile Data Operations: Wisconsin Energy
- User Interface Design/Integration Strategy for CRM & Mobile Data Operations: NIPSCO

EXHIBIT C

Video & Entertainment

25 March 2021

Hyphametrics comes out swinging with hyper-surveillance attribution

By Rafi Cohen

Hyphametrics is an audience measurement start-up that does not take the buzzwords 'cross-platform' and 'holistic' lightly. While still in its infancy, Hyphametrics could assemble a highly accurate dataset that will be hard to match in terms of transparency, if all goes to plan.

This prediction is based on how Hyphametrics performs hyper-surveillance on every aspect of digital entertainment in the home by scrupulously tracking everything from the feed displayed on the TV, to the IP traffic on the router, and even the locations of people in the house. It sounds spooky, but this Big Brother-esque measurement is reserved for a select set of opt-in panel audiences.

Talking to Faultline this week, Hyphametrics CEO, Joanna Drews, and CTO, Gerardo Lopez, talked us through the ins and outs of its proprietary system. At the hub of the house is the coreMeter box, which hosts multiple HDMI inputs for outgoing feeds from all TVs, gaming consoles, and set tops. Frame by frame analysis is conducted on those feeds, with different techniques applied depending on the source of the media.

A set top feed will be examined for broadcaster logos, as well as the channel information overlays that appear when a channel is changed, whereas a games console feed will be analyzed for browsing of the console interface to identify which game is selected, as well as developer logos at the start of gameplay.

Similarly, user choices on OTT platforms are tracked by following the user path towards content. Both Drews and Lopez feel this makes Hyphametrics the only measurement vendor that truly knows what people are watching. "We know that it is Season 3, Episode 6 of Seinfeld, not just a random sitcom," Lopez told us.

Keen to poke some holes, we asked whether Hyphametrics would be able to detect a pirated streaming website that is being displayed on the TV by either casting or HDMI? Lopez told us that while coreMeter would not be able detect this through its HDMI inputs, the wider system would be able to do so through IP traffic tracking.

The coreMeter is multi-tasking several capabilities simultaneously. As well as being an interface for HDMI feeds, the box acts as a router for network traffic measurement, and a quasi-connected TV from which OTT applications can be run (and measured.)

"We are replicating the CTV experience from our box. Any app they can have in their smart TV they can download here," Drews explained.

'Source of truth' is another buzzterm that often makes us switch off when hearing from measurement vendors, but Drews was keen to prove that Hyphametrics was not just spouting marketing fluff.

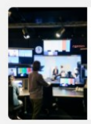
"We are never making a guess or an inference. While many competitors are reliant on libraries and schedule data, so there is always an inference made in the methodology, we are officially measuring who is in the room," Drews assured us.

Take measurement rival Samba TV, which Drews felt was a fitting example. "Samba TV works through TV manufacturers, which allows for scale, but it blocks measurement on all the top apps, and cannot tell you how many people are watching," she explained. "It makes ID matches with partners like Xperi, but those are loaded with inferences. It is not enough to provide granularity."

Hyphametrics can also tell who in the house is watching the TV at any moment by tracking the presence of users' mobile phones via Bluetooth and WiFi, which panelists agree to have turned on at all times. "We are officially measuring who is in the room and what they are exposed to," Lopez assured us.

Forecasts & Data
from Rethink TV

22 October 2021
Decentralized CDN and Multi-CDN Forecast 2021-2026



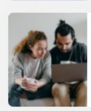
6 September 2021
Cloud Production Technologies – Market Forecast 2021-2026

8 July 2021
Set Top Box, Smart TV, and Connected TV Device Operating System Forecast – 2020-2026

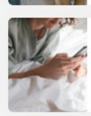
30 April 2021
Media & Entertainment Transcoding Workload and Device Royalty Forecast 2020-2030

19 February 2021
OTT Security market reaches $452 million, as live sports draw nearer to the direct-to-consumer cliff-edge

4 January 2021
Pay TV and Broadband place their last chips on understanding the customer



28 September 2020
CDN and WebRTC Video Forecast 2020-2025



23 July 2020
New Kids on the Block – the next video wave

Naturally, any company claiming such a competitive edge should be appropriately protected. Hyphametrics has just been issued its first patent, which Drews said covers 15 unique elements of its methodology, including the tracking of IP traffic, the use of certain ML algorithms, as well as the proprietary hardware, software and cloud technologies that are used.

Hyphametrics is in the process of recruiting its first preliminary panel of 100 households. "We know the market expectation in terms of neutrality, and we do not augment households. There will be some with every SVoD app, and other with just an antenna," explained Drews, meaning that a panel household is left as is, with no extra SVoD subscriptions, games consoles or set tops added.

Drews expects the panel to be reflective of the US within the first few hundred households, and once the panel hits 5,000 households, clients will be able to integrate its findings with census data to produce ratings.

So, who are these clients? Drews was unable to name any of the data platforms and media companies that were showing interest, but did say that its main focus is streaming platforms. "Networks are pumping ad dollars into those spaces, so those platforms need to better understand the user and their competitors," she explained. "What is a Pluto TV user doing when not on the platform?"

Interestingly, Drews did say that the likes of Nielsen and Comscore would find value in Hyphametrics' offering, suggesting it is not rival but rather a complementary service.

Being early days, Hyphametrics is not breaking out data on certain trends – like Nielsen and Comscore have done with D2C movies – but this is coming. "We have already entered into market conversations with interest in specific subsets. We have a proprietary system built from scratch, so it is a small lift," Drews told us.

Early interest is in IP traffic measurement, specifically seeing how effective ad placement matches internet browsing, as well as the more general interplay between all entertainment devices in the home.

Bitmovin weighs in on guiding Eventive's hypergrowth

Attempts by NBCU, Roku to disrupt ad formats fall flat

To contact Rethink please email us at info@rethinkresearch.biz
Alternatively call us on +44 (0)1179 257019

EXHIBIT D

HyphaMetrics Issued Patent for Cross-Platform Measurement

By Jon Lafayette March 10, 2021

Single-source system based on optical recognition, A.I. and machine learning

HyphaMetrics got a patent for its cross-platform measurement system (Image credit: HyphaMetrics)

HyphaMetrics, an independent media measurement company, was issued a U.S. patent for its next-generation cross-platform measurement system.

Patent No. 10,932,002 covers the company's unique coreMeter hardware, its methodology for collecting data from all media sources in a household, and how the company determines individuals' media consumption within a household.

HyphaMetrics' system "can facilitate the measurement of everything occurring in someone's home. We're able to measure across all the walled gardens, across all the various silos," said CEO and co-founder Joanna Drews. "What that produces is a true cross-platform single-source metric."

The patent will enable HyphaMedia to deploy a "complete proprietary measurement system that

is absolutely going to solve for a lot of the Holy Grail issues about omni-channel, cross-screen person-level measurement that the entire industry has been debating and asking for for a very long time," said Mike Bologna, the long-time advanced advertising head at GroupM who joined HyphaMetrics as chief revenue officer last year.

Joanna Drews, co-founder and CEO, HyphaMetrics (Image credit: HyphaMetrics)

Drews was director of product management and emerging assets at Comscore and a partner in GroupM's research practice.

Large measurement companies including Nielsen and Comscore are working on their own cross-media measurement systems.

Drews sees HyphaMetrics as a compliment for those systems, rather than a replacement.

"All of those solutions are really great at scale. They lack the granularity and the definition that we provide," she said, adding someday, Nielsen might be one of HyphaMetric's customers.

HyphaMetrics is in pilot mode now, according to Bologna.

Michael Bologna (Image credit: HyphaMetrics)

"We are about to launch a field trial," he said, putting its coreMeter boxes into about 100 homes while working with a few select partners." He did not name the partners.

Bologna noted that the boxes are costly and that it's expensive to recruit panels. The company previously raised $2 million, but will be raising additional funds via an equity round of financing in order to continue growing.

A lot of measurement systems use audio content recognition or automatic content recognition to determine what's being watched. HyphaMetrics' technology uses artificial intelligence and machine learning to read what's on the screen, Drews said. Its boxes are attached to each TV in a household. The boxes also have a router that enabled them to determine what's being watched on streaming devices.

The systems allow HyphaMetrics to determine co-viewing, viewing personas and household viewing, Drews said.

HyphaMetrics' three products so far are ClearviewMetrics, which measures unduplicated viewing data at the individual level across every network, program, advertisement, product placement, streaming app, gaming environment for every single device in the household; ContentMetrics, which collects real time data about who is watching what content and in what format -- live, time-shifted, or streaming – on TVs within an entire household; and MobileMetrics, granular data which demonstrates time spent in apps, simultaneous app usage, multitasking metrics, and more across mobile media environments.

EXHIBIT E

US010932002B2

(12) **United States Patent**
Zamudio et al.

(10) **Patent No.: US 10,932,002 B2**
(45) **Date of Patent: Feb. 23, 2021**

(54) **CROSS-MEDIA MEASUREMENT DEVICE AND METHOD**

(71) Applicant: **Hyphametrics, Inc.**, Albany, NY (US)

(72) Inventors: **Gerardo Lopez Zamudio**, Mexico City (MX); **Joanna Drews**, Derwood, MD (US)

(73) Assignee: **Hyphametrics, Inc.**, Albany, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/925,029**

(22) Filed: **Jul. 9, 2020**

(65) **Prior Publication Data**

US 2021/0014565 A1 Jan. 14, 2021

Related U.S. Application Data

(60) Provisional application No. 62/871,789, filed on Jul. 9, 2019.

(51) **Int. Cl.**

H04H 60/32	(2008.01)
H04N 21/442	(2011.01)
G06K 9/00	(2006.01)
H04N 21/258	(2011.01)
H04N 21/4402	(2011.01)
H04N 21/466	(2011.01)
G06N 20/00	(2019.01)
G06N 5/04	(2006.01)
H04N 21/81	(2011.01)
G06Q 30/02	(2012.01)

(52) **U.S. Cl.**
CPC ... ***H04N 21/44222*** (2013.01); ***G06K 9/00744*** (2013.01); ***G06N 5/04*** (2013.01); ***G06N 20/00*** (2019.01); ***H04N 21/25883*** (2013.01); ***H04N 21/4402*** (2013.01); ***H04N 21/4662*** (2013.01); ***H04N 21/812*** (2013.01); *G06K 2209/25* (2013.01); *G06Q 30/0242* (2013.01); *G06Q 30/0272* (2013.01)

(58) **Field of Classification Search**
CPC H04N 21/44222; H04N 21/25883; H04N 21/4402; H04N 21/4662; H04N 21/812
USPC 725/14
See application file for complete search history.

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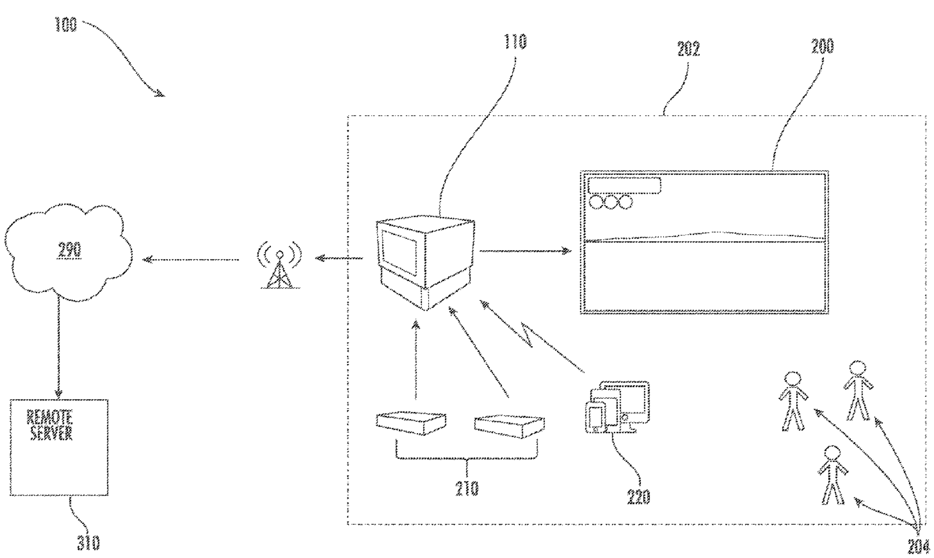
(Continued)

Primary Examiner — Pankaj Kumar
Assistant Examiner — Sahar Aqil Riaz
(74) *Attorney, Agent, or Firm* — Maginot, Moore & Beck LLP

(57) **ABSTRACT**

A method of identifying media content presented on a display device includes determining a selected input source providing a video signal to the display device, and then selecting a first set of content identification rules when it is determined that the selected input source is a first input source, and selecting a second set of content identification rules when it is determined that the selected input source is a second input source. The method further comprises applying the selected first set or second set of content identification rules to the video signal in order to generate content identification data for the media content presented on the display device. Application of the content identification rules includes waiting for a trigger event and applying an algorithm to one or more frames of the video signal following the trigger event.

20 Claims, 43 Drawing Sheets



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2020/0228880	A1 *	7/2020	Iyer	H04N 21/23424
2020/0236415	A1 *	7/2020	Khanna	H04N 21/2353
2020/0296472	A1 *	9/2020	Chung	H04N 21/4826

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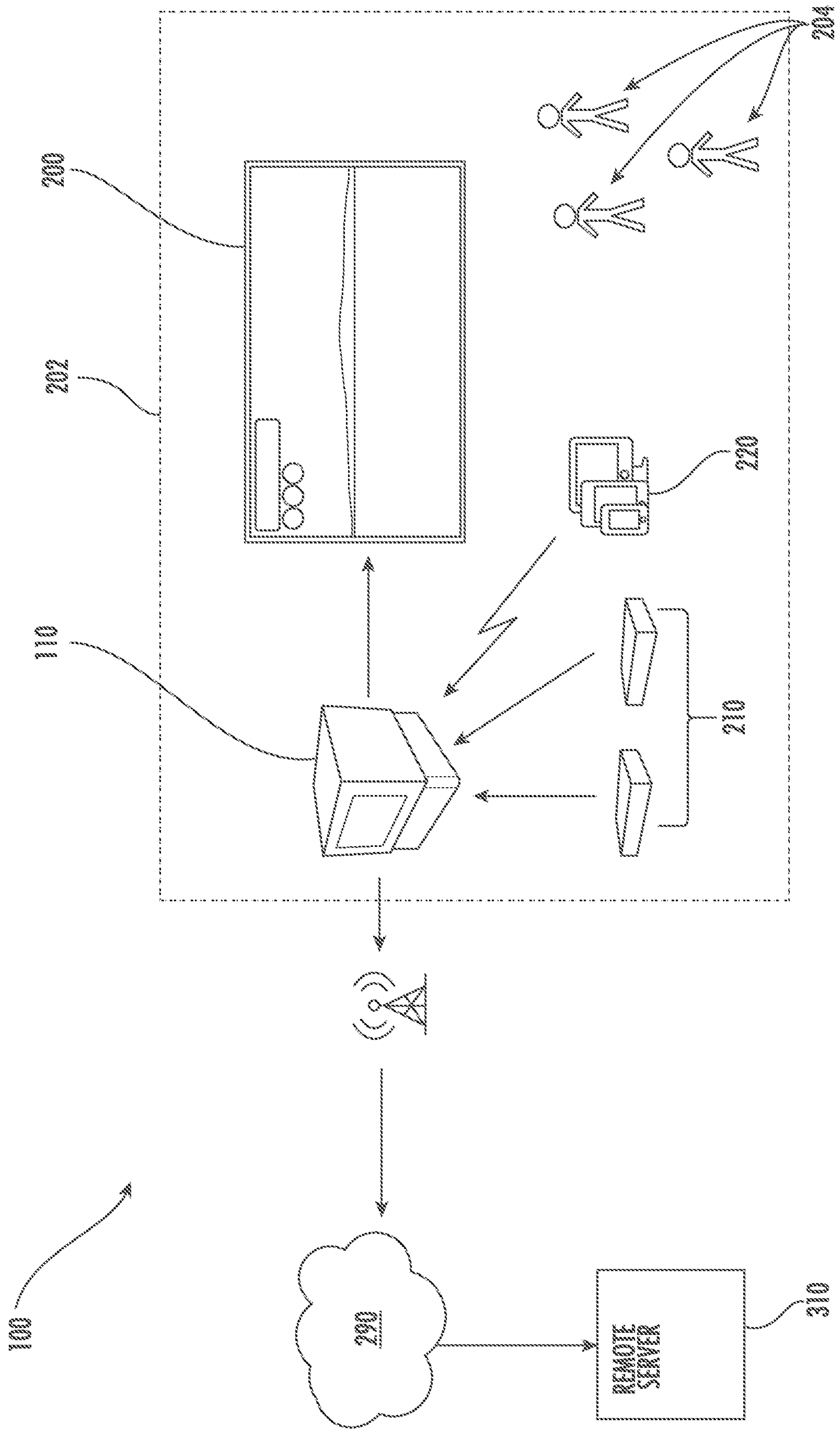


FIG. 1

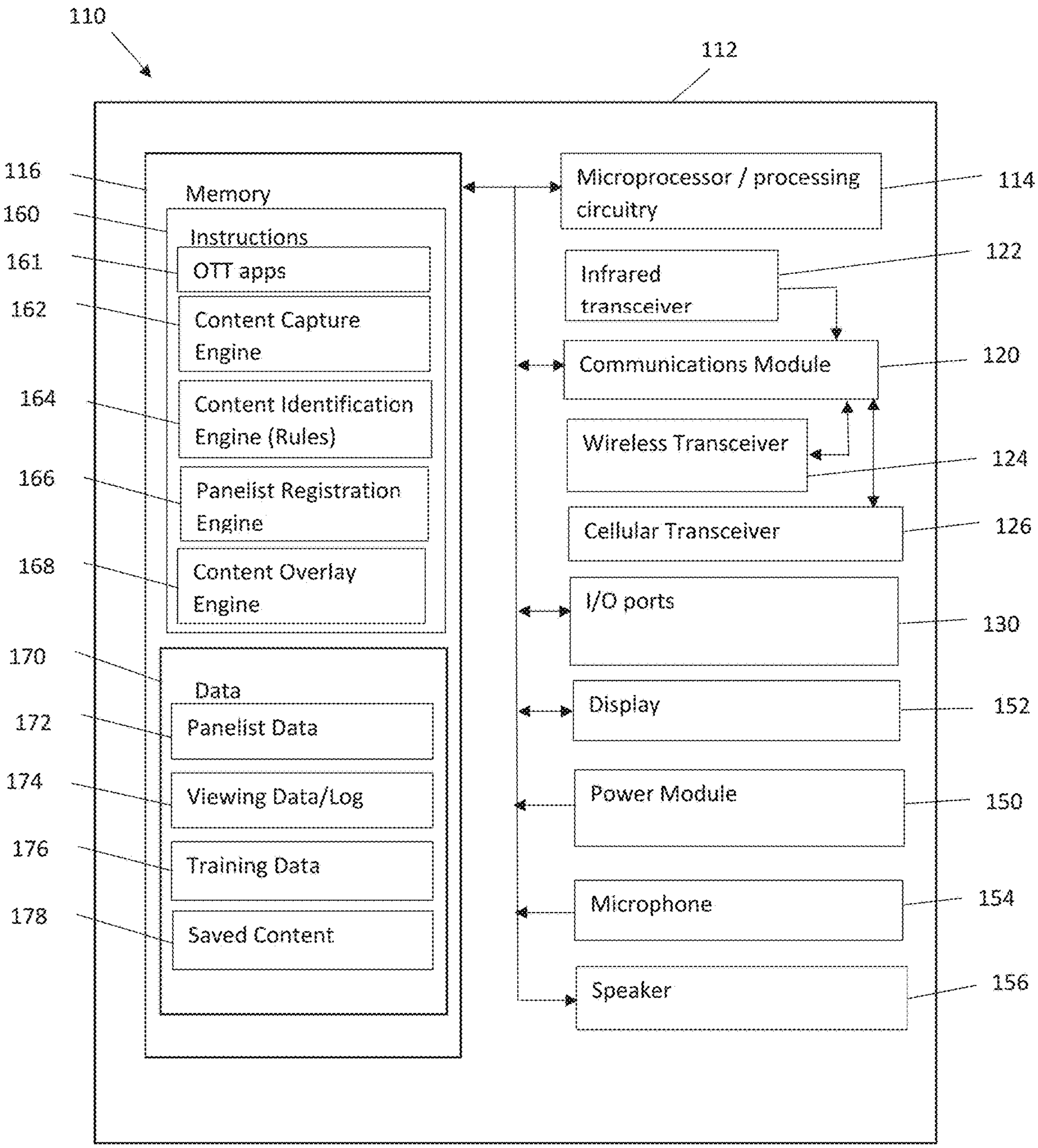
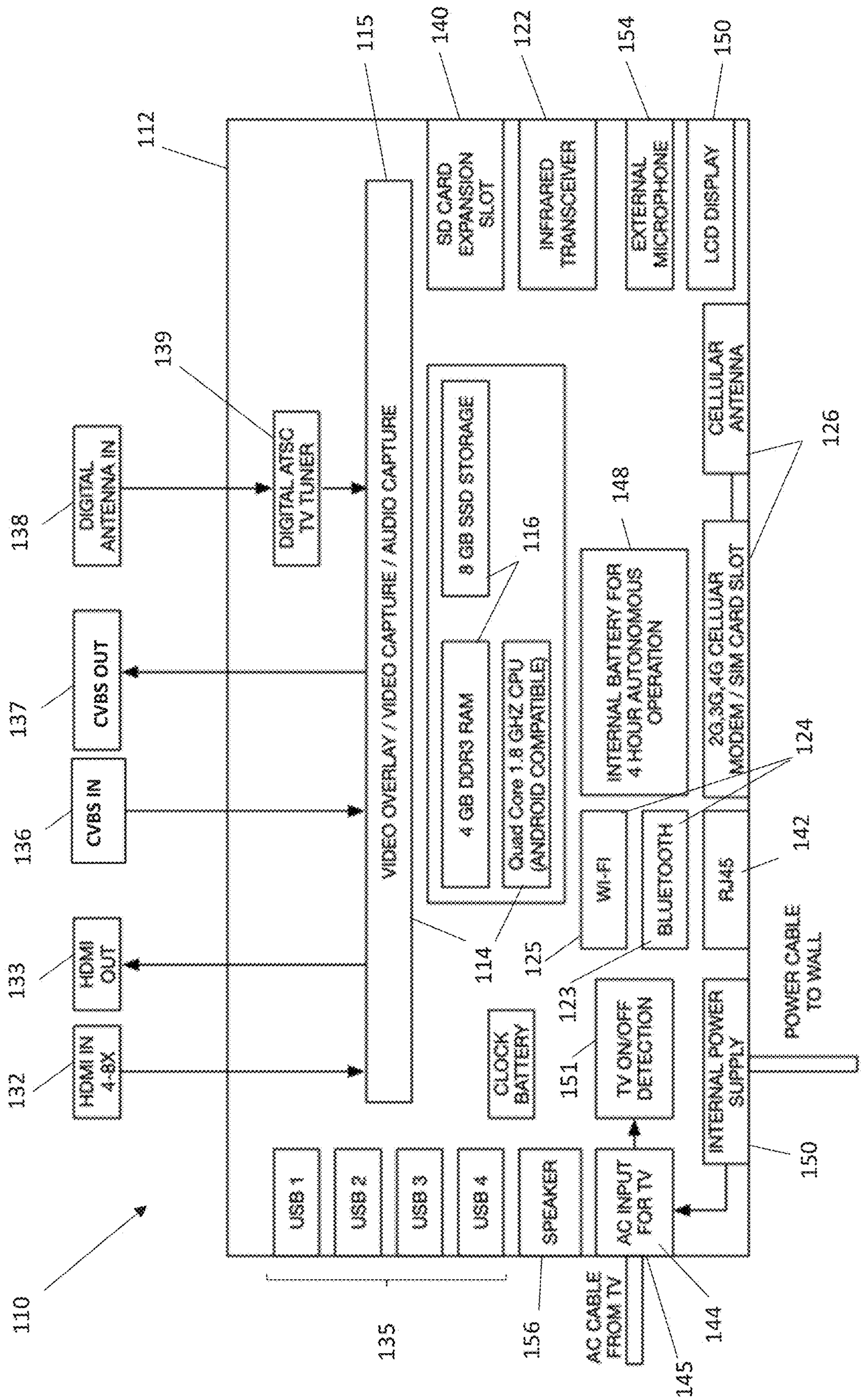

110
112
116
160
161
162
164
166
168
170
172
174
176
178
Memory
Instructions
OTT apps
Content Capture Engine
Content Identification Engine (Rules)
Panelist Registration Engine
Content Overlay Engine
Data
Panelist Data
Viewing Data/Log
Training Data
Saved Content
Microprocessor / processing circuitry
114
Infrared transceiver
122
Communications Module
120
Wireless Transceiver
124
Cellular Transceiver
126
I/O ports
130
Display
152
Power Module
150
Microphone
154
Speaker
156

FIG. 2A



112
115
140
122
154
150
SD CARD EXPANSION SLOT
INFRARED TRANSCEIVER
EXTERNAL MICROPHONE
LCD DISPLAY
139
138
DIGITAL ANTENNA IN
DIGITAL ATSC TV TUNER
VIDEO OVERLAY / VIDEO CAPTURE / AUDIO CAPTURE
8 GB SSD STORAGE
116
CELLULAR ANTENNA
126
148
137
CVBS OUT
4 GB DDR3 RAM
Quad Core 1.8 GHZ CPU (ANDROID COMPATIBLE)
INTERNAL BATTERY FOR 4 HOUR AUTONOMOUS OPERATION
2G,3G,4G CELLULAR MODEM / SIM CARD SLOT
124
136
CVBS IN
WI-FI
BLUETOOTH
RJ45
142
133
HDMI OUT
114
125
123
POWER CABLE TO WALL
132
HDMI IN 4-8X
CLOCK BATTERY
151
TV ON/OFF DETECTION
INTERNAL POWER SUPPLY
150
110
USB 1
USB 2
USB 3
USB 4
SPEAKER
AC INPUT FOR TV
135
156
AC CABLE FROM TV
144
145

FIG. 2B

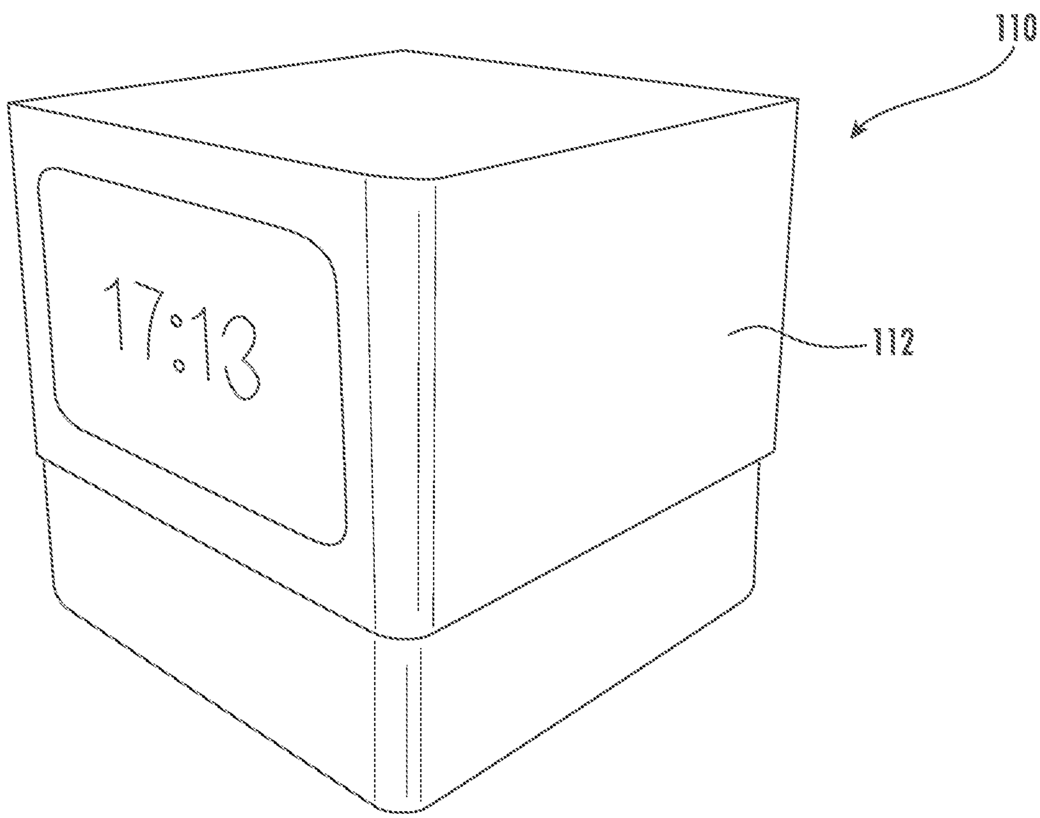


FIG. 2C

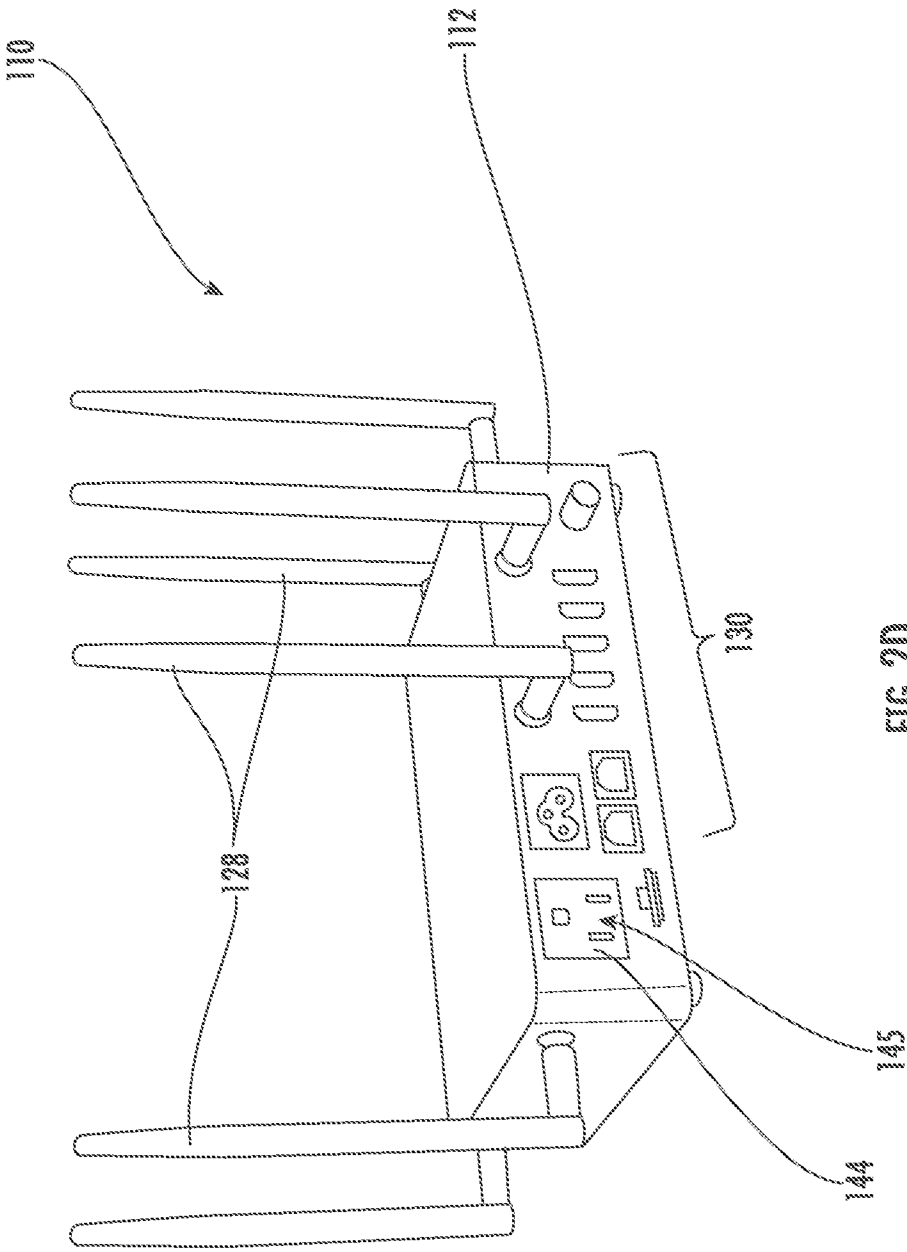


FIG. 2D

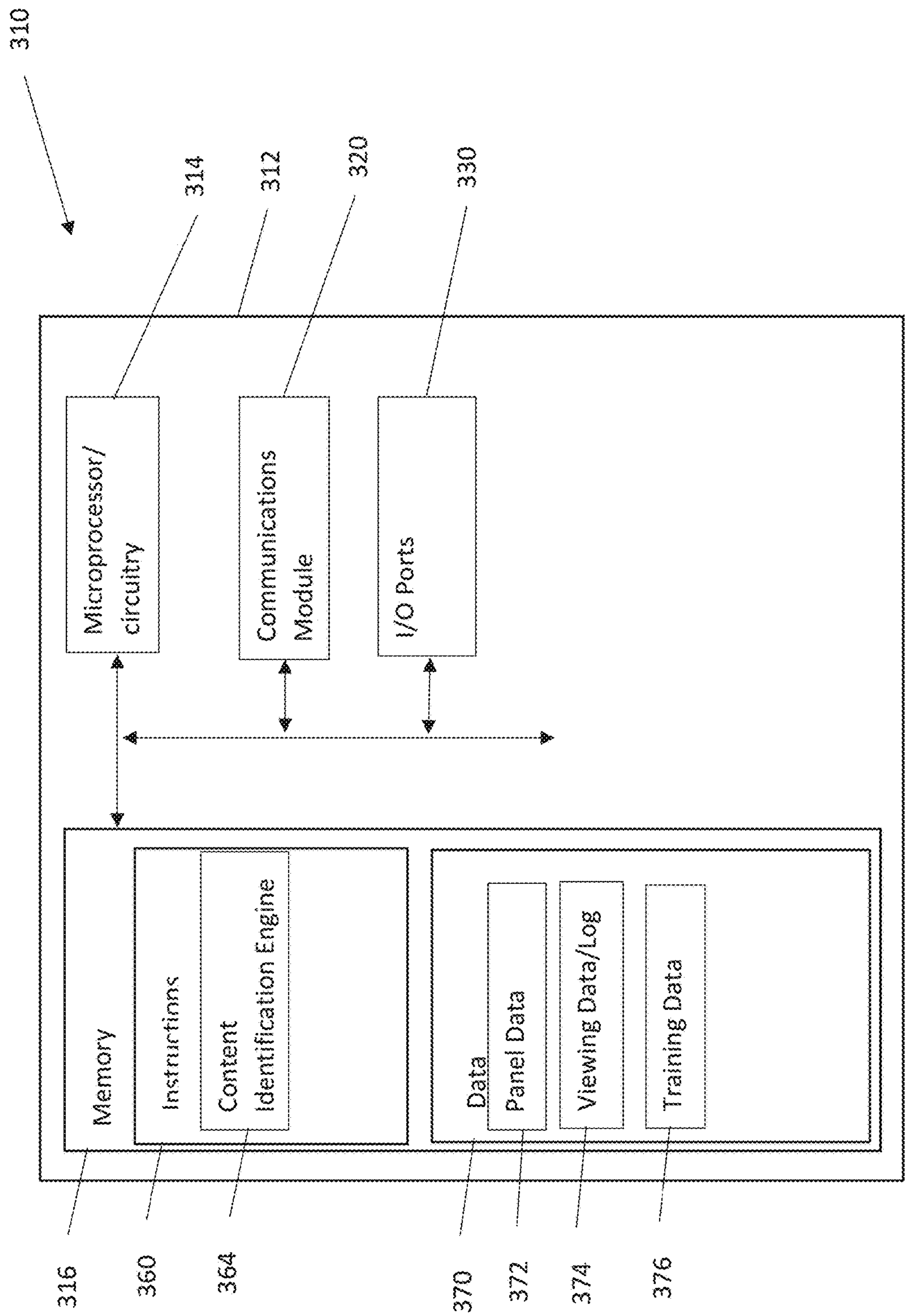

310
314
312
320
330
Microprocessor/
circuitry
Communications
Module
I/O Ports
Memory
Instructions
Content
Identification Engine
Data
Panel Data
Viewing Data/Log
Training Data
316
360
364
370
372
374
376

FIG. 3

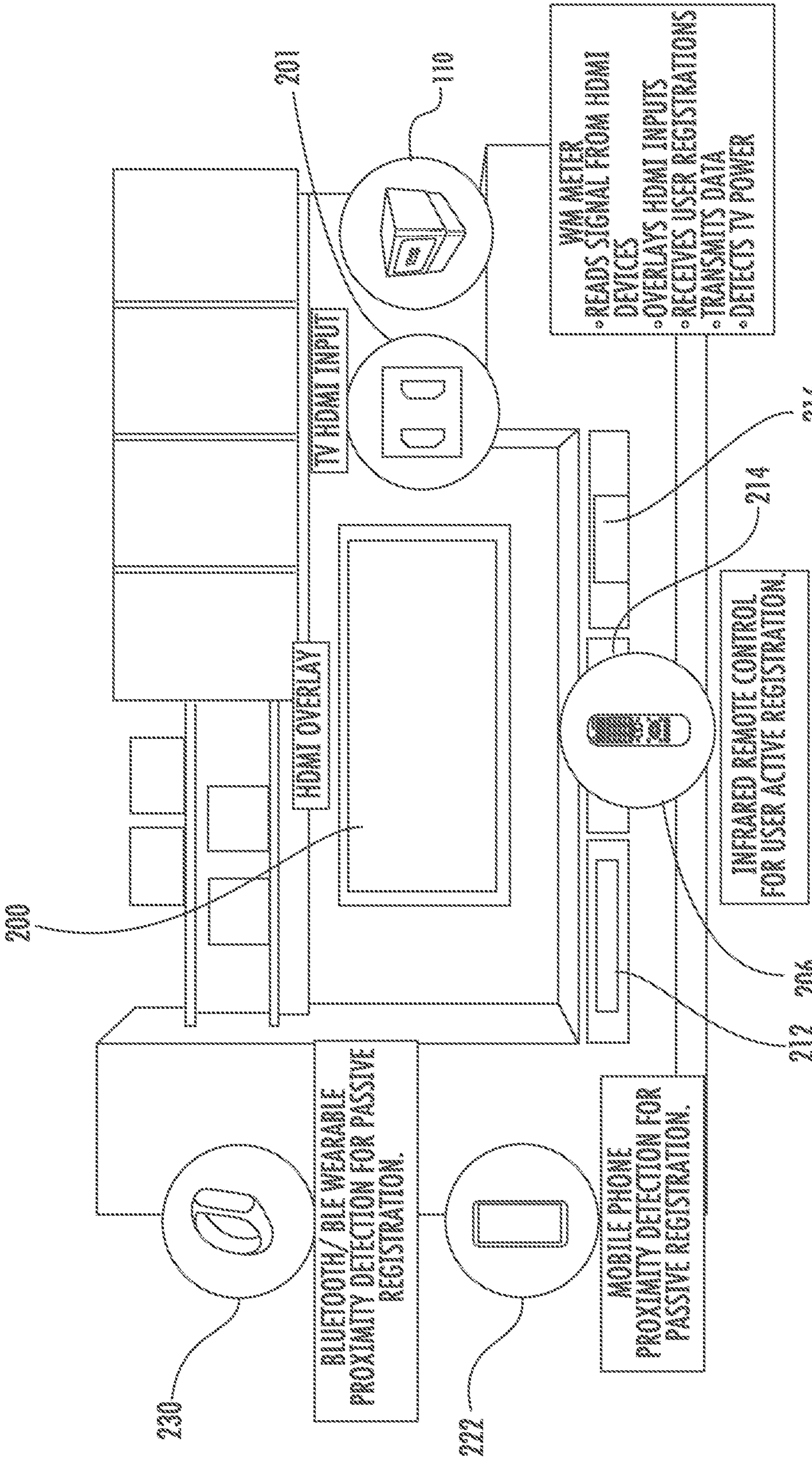

201
110
WM METER
• READS SIGNAL FROM HDMI DEVICES
• OVERLAYS HDMI INPUTS
• RECEIVES USER REGISTRATIONS
• TRANSMITS DATA
• DETECTS TV POWER
TV HDMI INPUT
216
214
HDMI OVERLAY
INFRARED REMOTE CONTROL FOR USER ACTIVE REGISTRATION.
200
206
212
BLUETOOTH/ BLE WEARABLE PROXIMITY DETECTION FOR PASSIVE REGISTRATION.
MOBILE PHONE PROXIMITY DETECTION FOR PASSIVE REGISTRATION.
230
222

FIG. 4

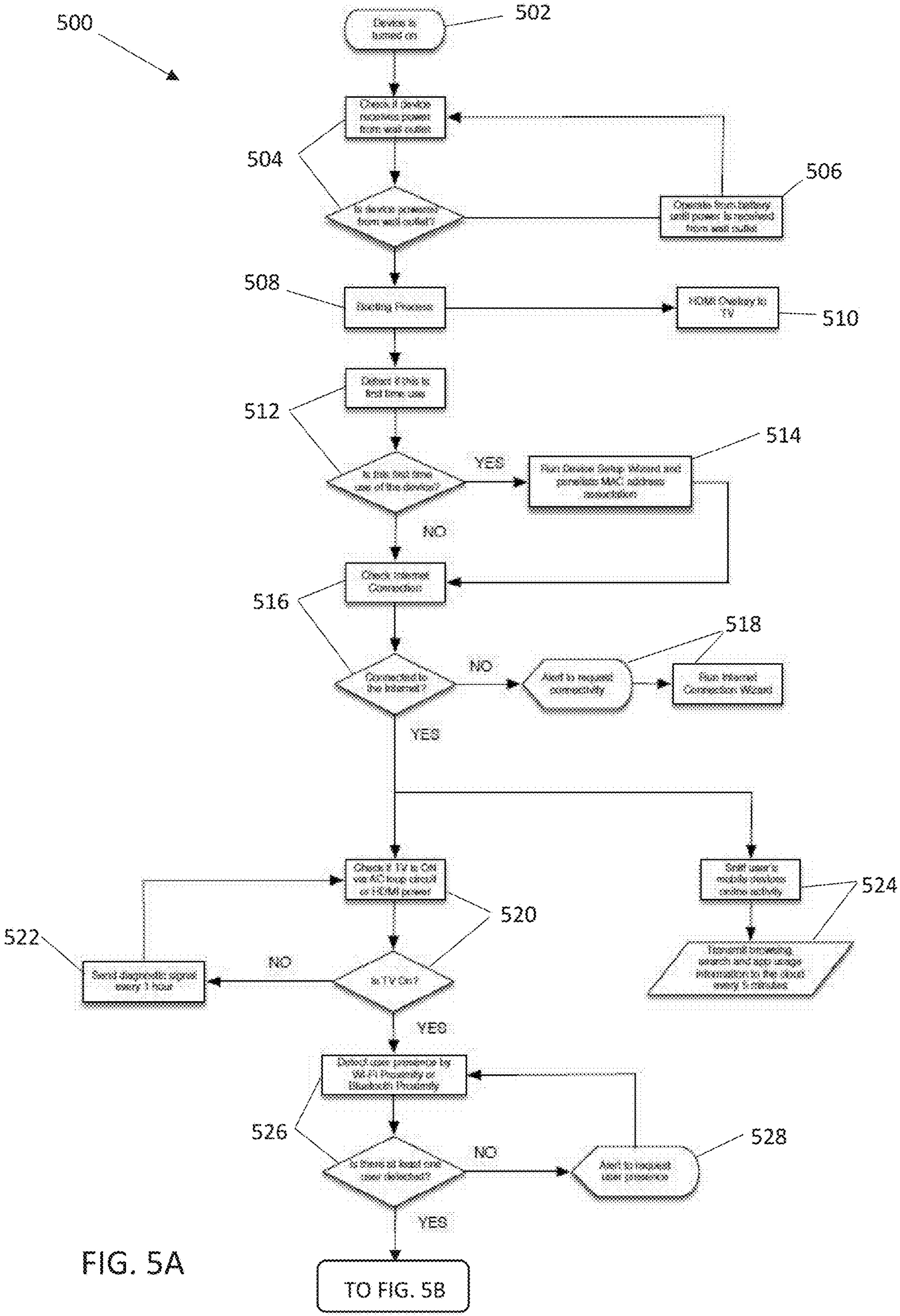

500
502
504
506
508
510
512
514
YES
NO
516
518
NO
YES
520
522
524
NO
YES
526
528
NO
YES
TO FIG. 5B

FIG. 5A

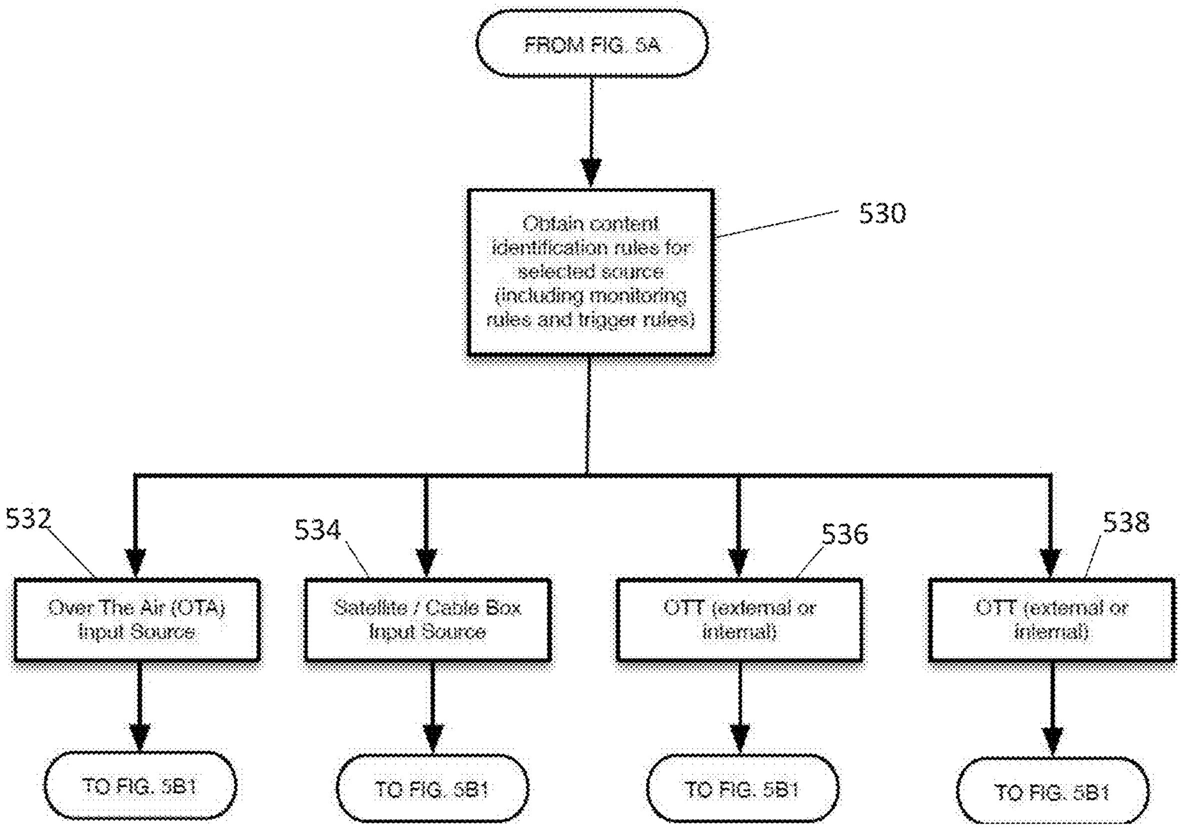

FROM FIG. 5A
Obtain content identification rules for selected source (including monitoring rules and trigger rules)
530
532
534
536
538
Over The Air (OTA) Input Source
Satellite / Cable Box Input Source
OTT (external or internal)
OTT (external or internal)
TO FIG. 5B1
TO FIG. 5B1
TO FIG. 5B1
TO FIG. 5B1

FIG. 5B

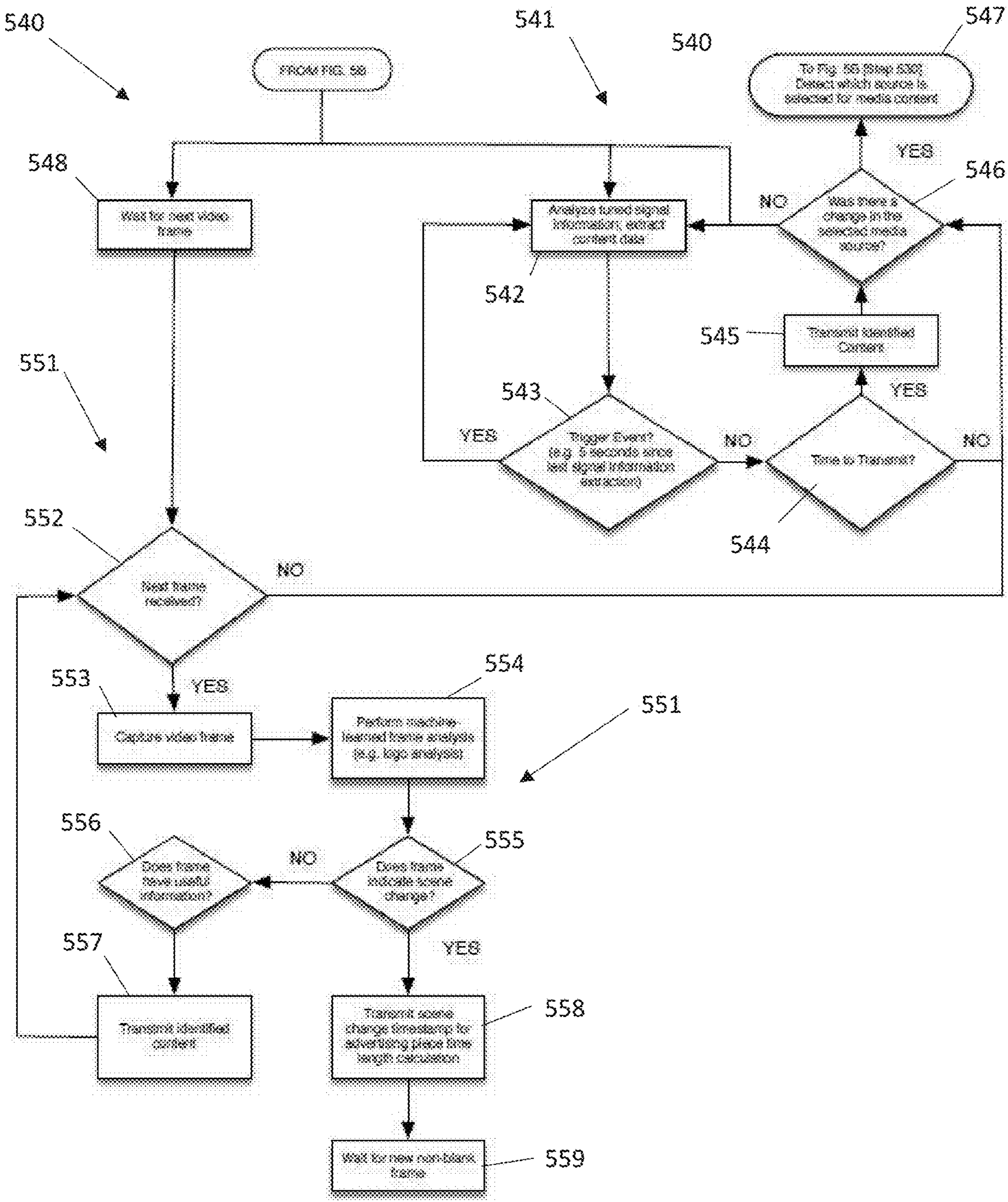

540
541
540
547
FROM FIG. 5B
To Fig. 5B (Step 530) Detect which source is selected for media content
548
Wait for next video frame
Analyze tuned signal information, extract content data
542
YES
546
NO
Was there a change in the selected media source?
545
Transmit Identified Content
551
543
YES
Trigger Event? (e.g. 5 seconds since last signal information extraction)
NO
Time to Transmit?
NO
544
552
Next frame received?
NO
553
YES
Capture video frame
554
Perform machine-learned frame analysis (e.g. logo analysis)
551
556
Does frame have useful information?
NO
Does frame indicate scene change?
555
557
YES
Transmit identified content
Transmit scene change timestamp for advertising place time length calculation
558
Wait for new non-blank frame
559

FIG. 5B1

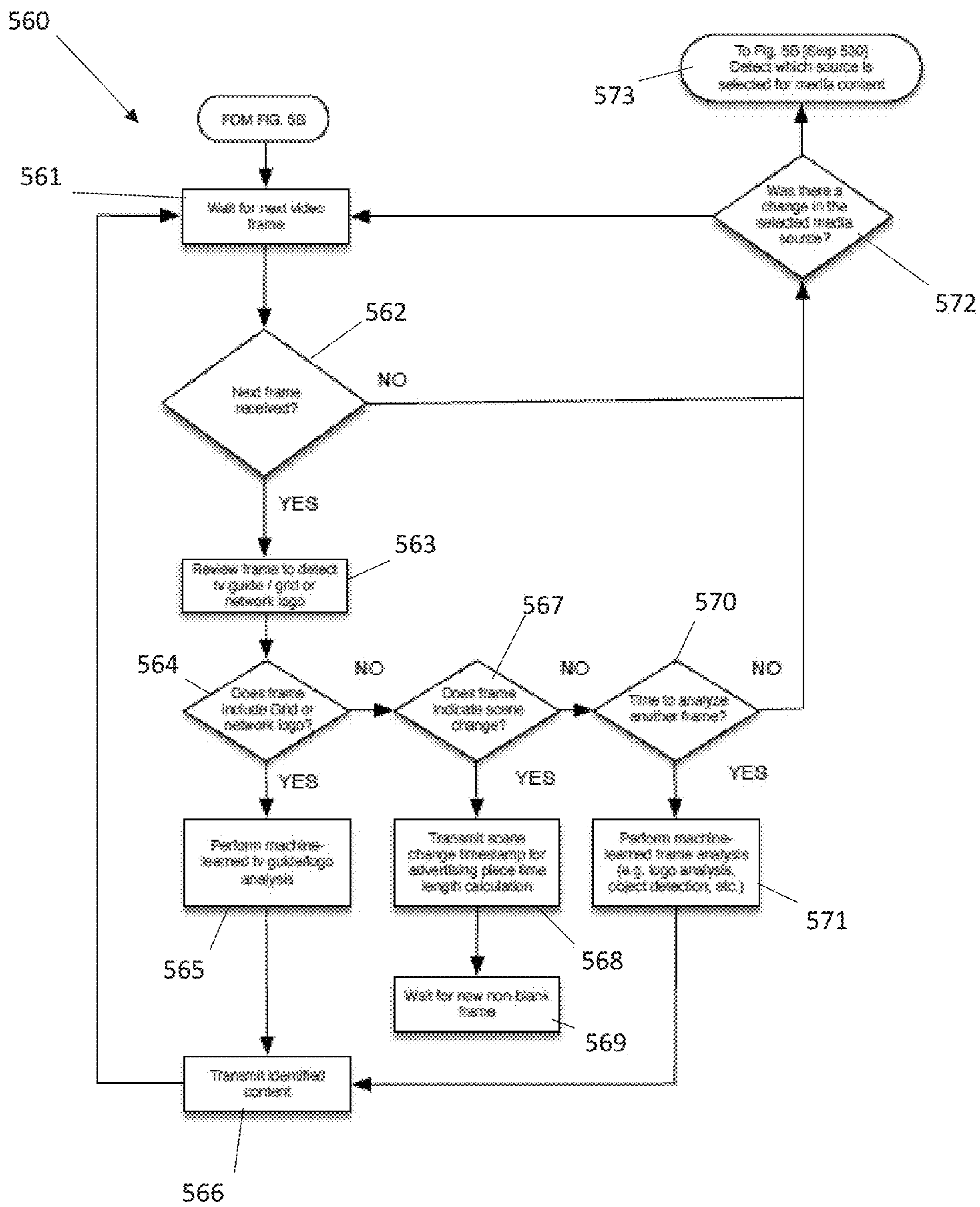

560
FOM FIG. 5B
561
Wait for next video frame
562
Next frame received?
NO
YES
563
Review frame to detect tv guide / grid or network logo
564
Does frame include Grid or network logo?
NO
YES
565
Perform machine-learned tv guide/logo analysis
567
Does frame indicate scene change?
NO
YES
568
Transmit scene change timestamp for advertising piece time length calculation
569
Wait for new non-black frame
570
Time to analyze another frame?
NO
YES
571
Perform machine-learned frame analysis (e.g. logo analysis, object detection, etc.)
566
Transmit identified content
572
Was there a change in the selected media source?
573
To Fig. 5B [Step 530] Detect which source is selected for media content

FIG. 5B2

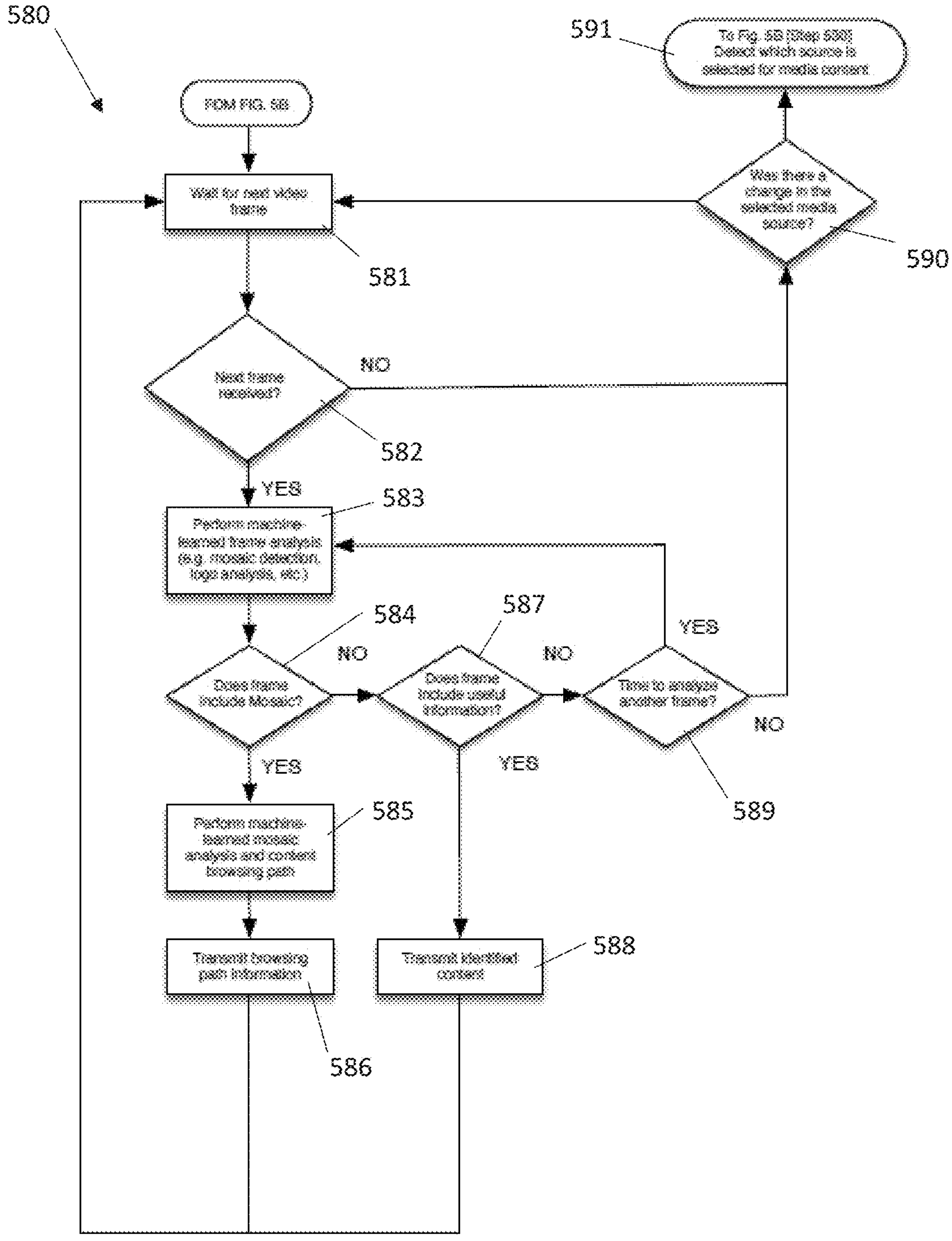

580
591
To Fig. 5B [Step 530]
Detect which source is
selected for media content
FOM FIG. 5B
Wait for next video
frame
Was there a
change in the
selected media
source?
590
581
Next frame
received?
NO
582
YES
583
Perform machine-
learned frame analysis
(e.g. mosaic detection,
logo analysis, etc.)
584
587
NO
NO
YES
Does frame
include Mosaic?
Does frame
include useful
information?
Time to analyze
another frame?
NO
YES
YES
585
589
Perform machine-
learned mosaic
analysis and content
browsing path
Transmit browsing
path information
Transmit identified
content
588
586

FIG. 5B3

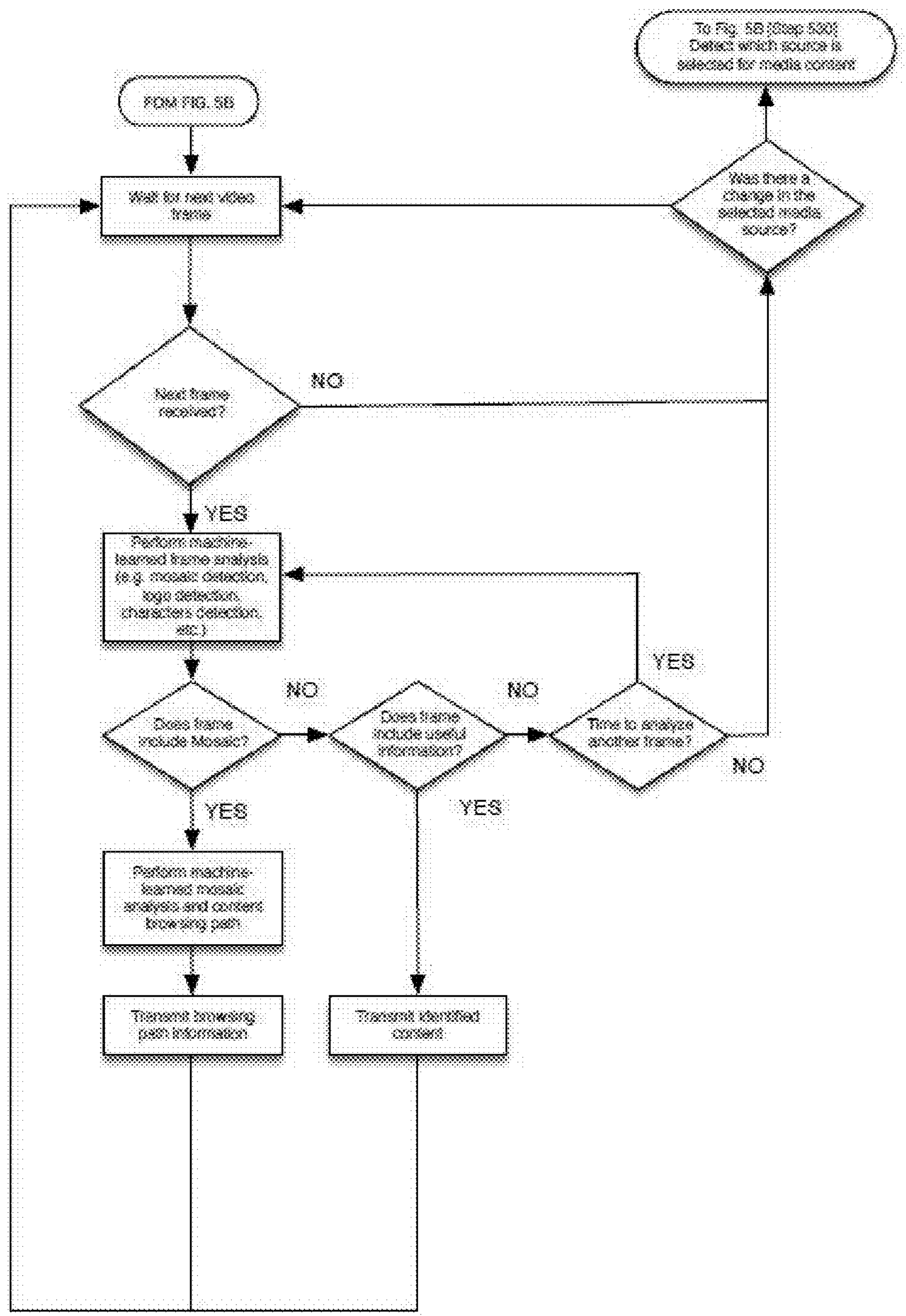

FOM FIG. 5B
Wait for next video frame
To Fig. 5B (Step 530) Detect which source is selected for media content
Was there a change in the selected media source?
Next frame received?
NO
YES
Perform machine-learned frame analysis (e.g. mosaic detection, logo detection, characters detection, etc.)
Does frame include Mosaic?
NO
Does frame include useful information?
NO
Time to analyze another frame?
YES
NO
YES
YES
Perform machine-learned mosaic analysis and content browsing path
Transmit browsing path information
Transmit identified content

FIG. 5B4

600

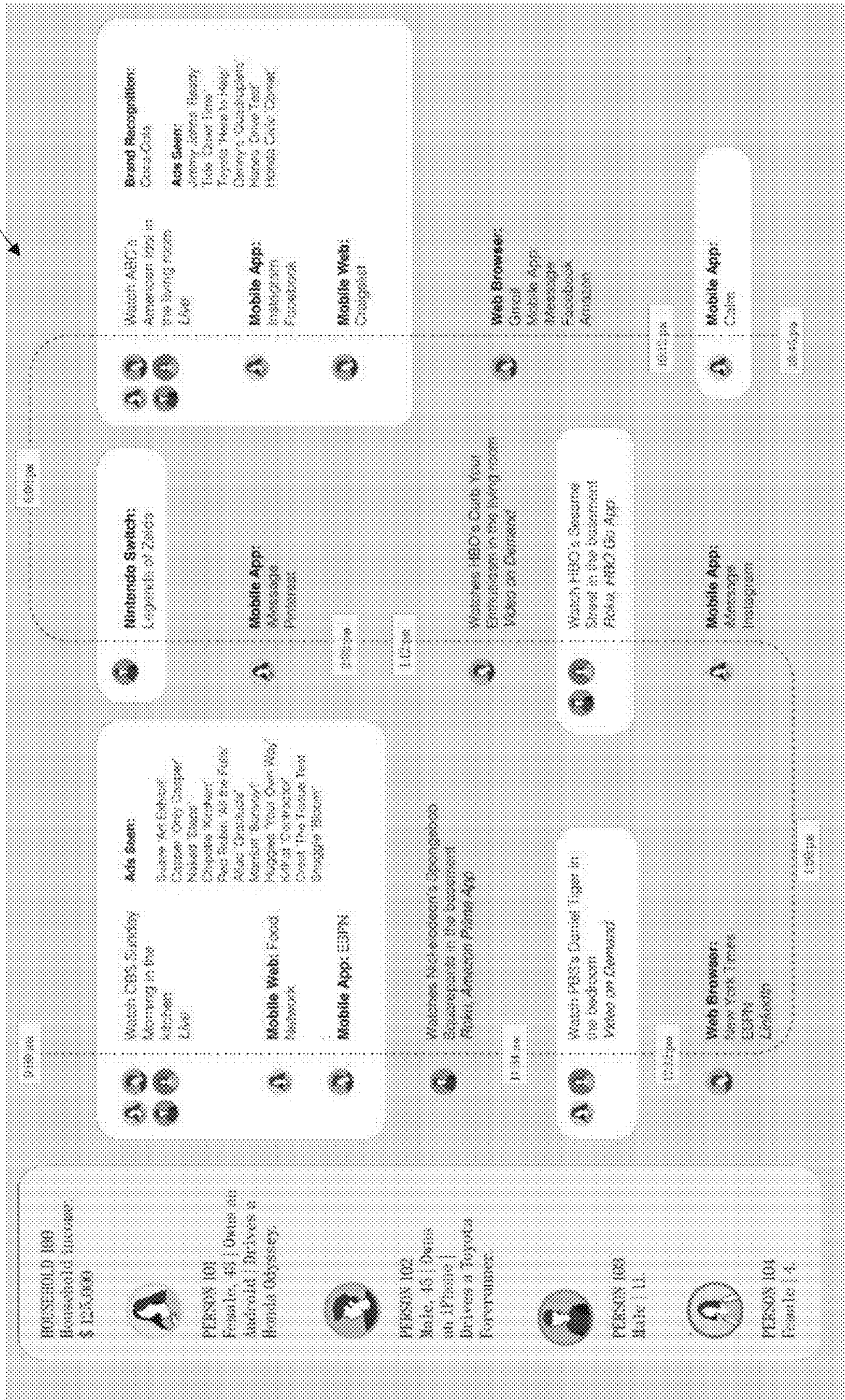


FIG. 6

700

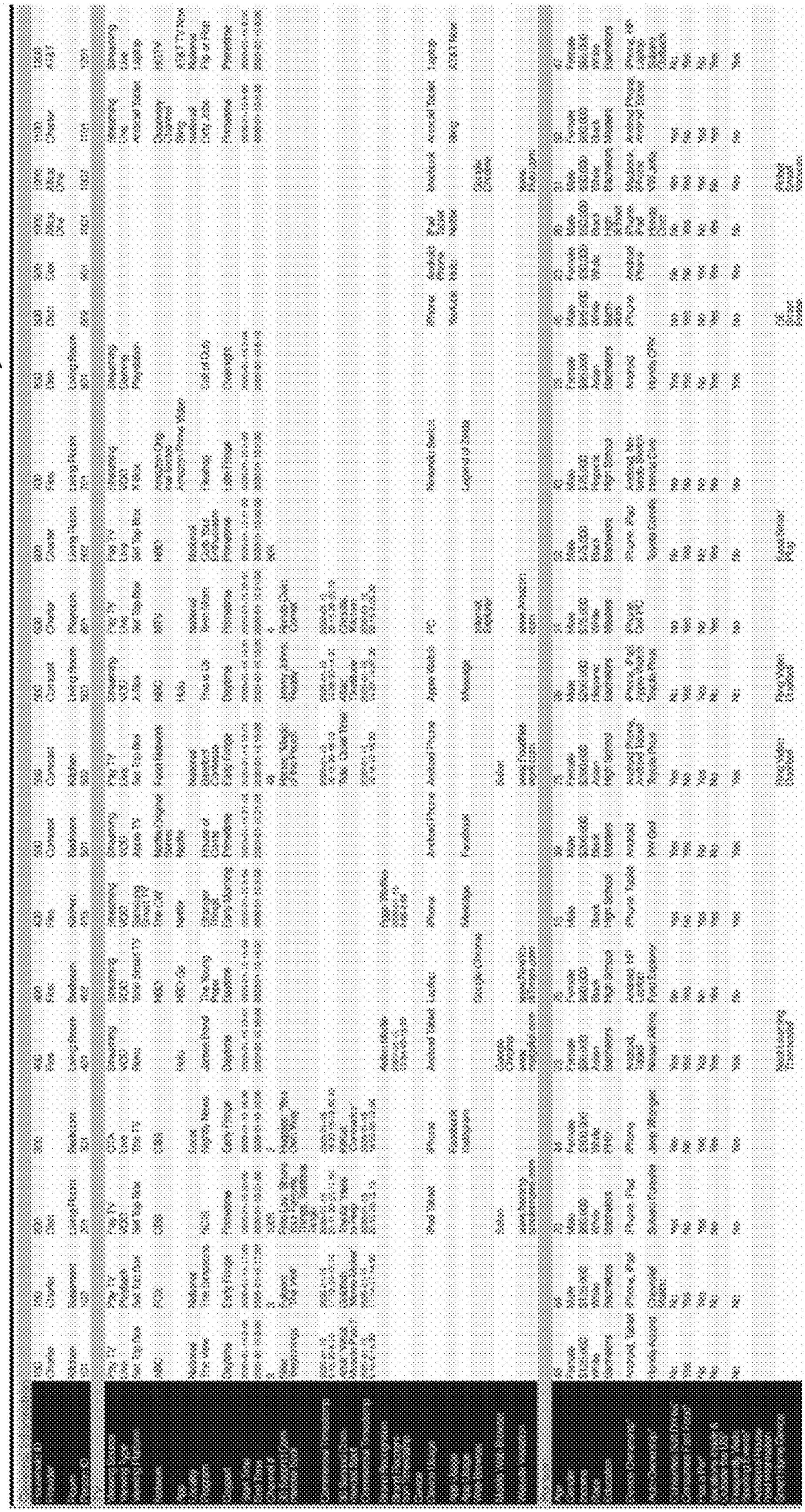


FIG. 7

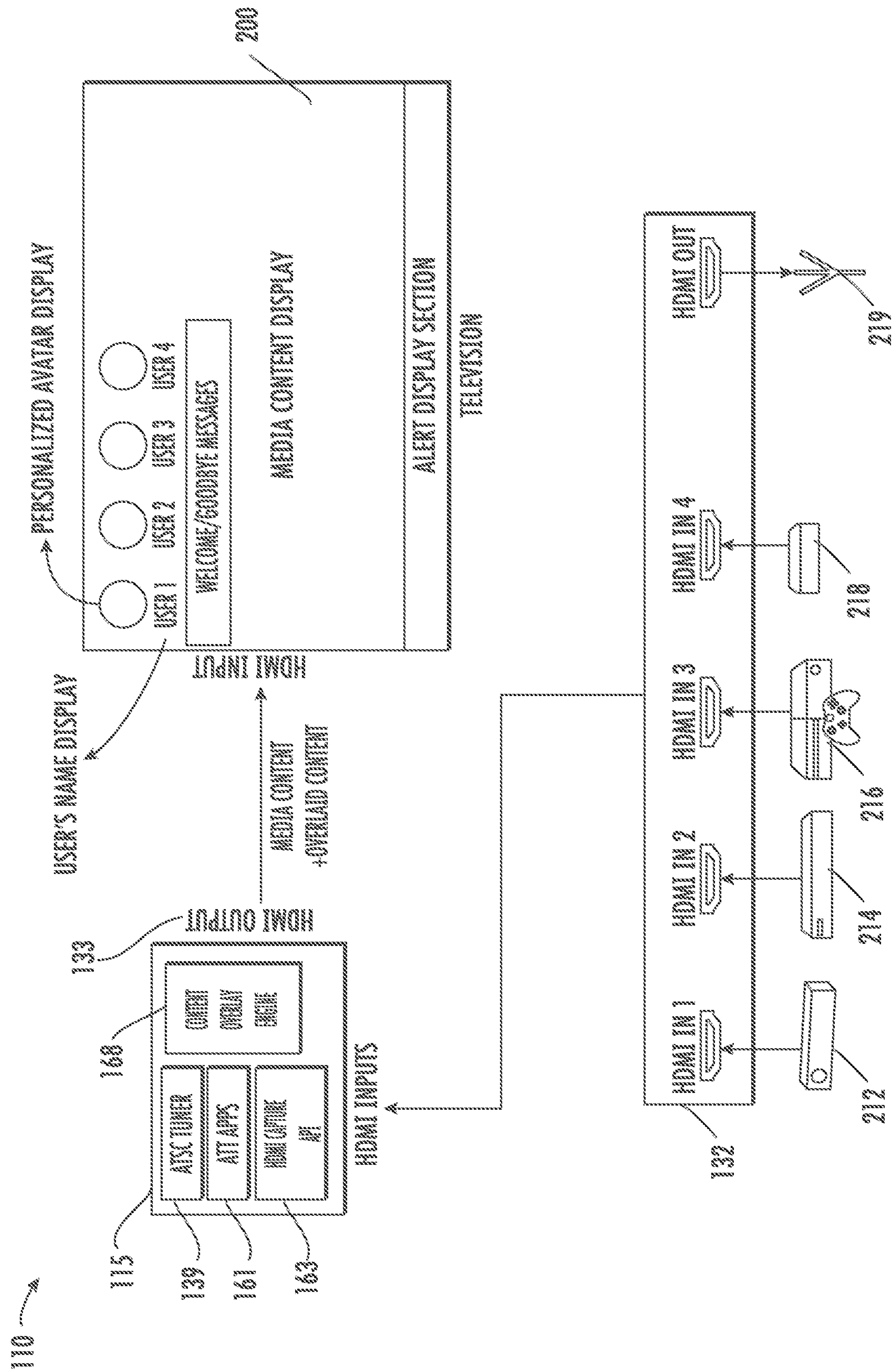

200
PERSONALIZED AVATAR DISPLAY
USER 1
USER 2
USER 3
USER 4
WELCOME/GOODBYE MESSAGES
MEDIA CONTENT DISPLAY
ALERT DISPLAY SECTION
TELEVISION
HDMI INPUT
USER'S NAME DISPLAY
MEDIA CONTENT
+OVERLAID CONTENT
HDMI OUTPUT
133
168
CONTENT
OVERLAY
ENGINE
ATSC TUNER
ATT APPS
HDMI CAPTURE
API
HDMI INPUTS
115
139
161
163
110
HDMI OUT
HDMI IN 4
HDMI IN 3
HDMI IN 2
HDMI IN 1
219
218
216
214
212
132

FIG. 8

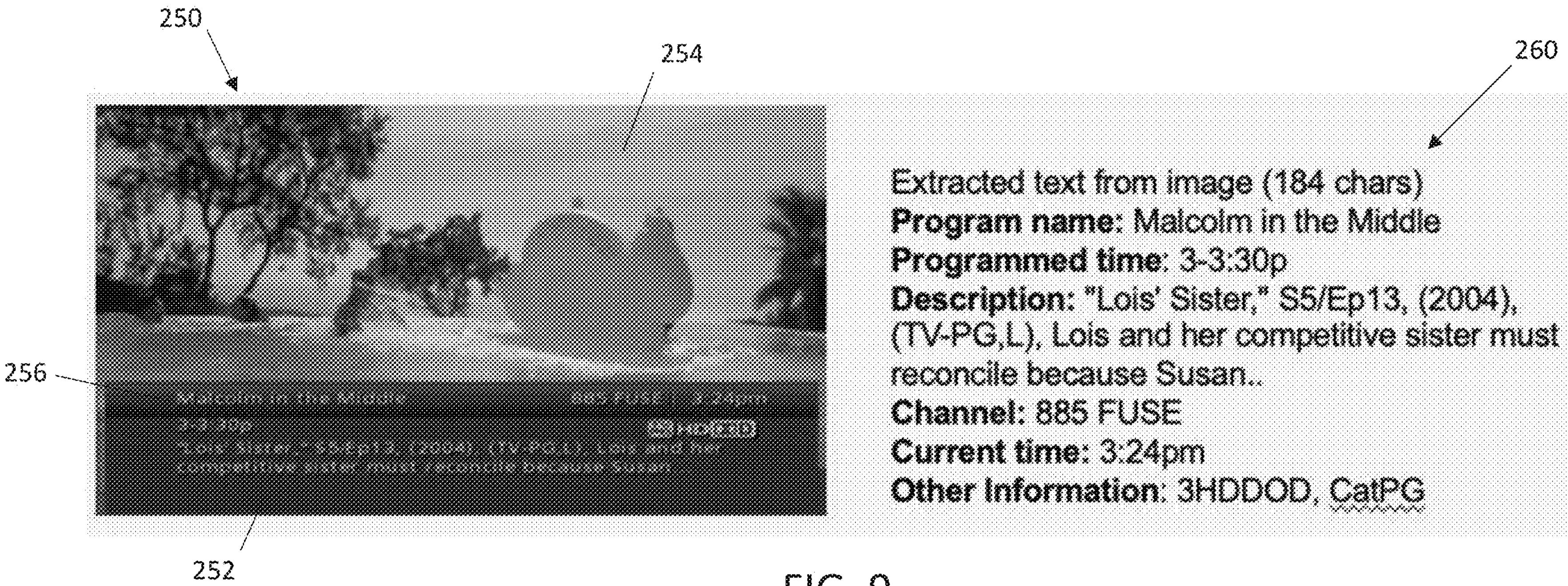

250
254
260
256
252
Extracted text from image (184 chars)
Program name: Malcolm in the Middle
Programmed time: 3-3:30p
Description: "Lois' Sister," S5/Ep13, (2004), (TV-PG,L), Lois and her competitive sister must reconcile because Susan..
Channel: 885 FUSE
Current time: 3:24pm
Other Information: 3HDDOD, CatPG

FIG. 9

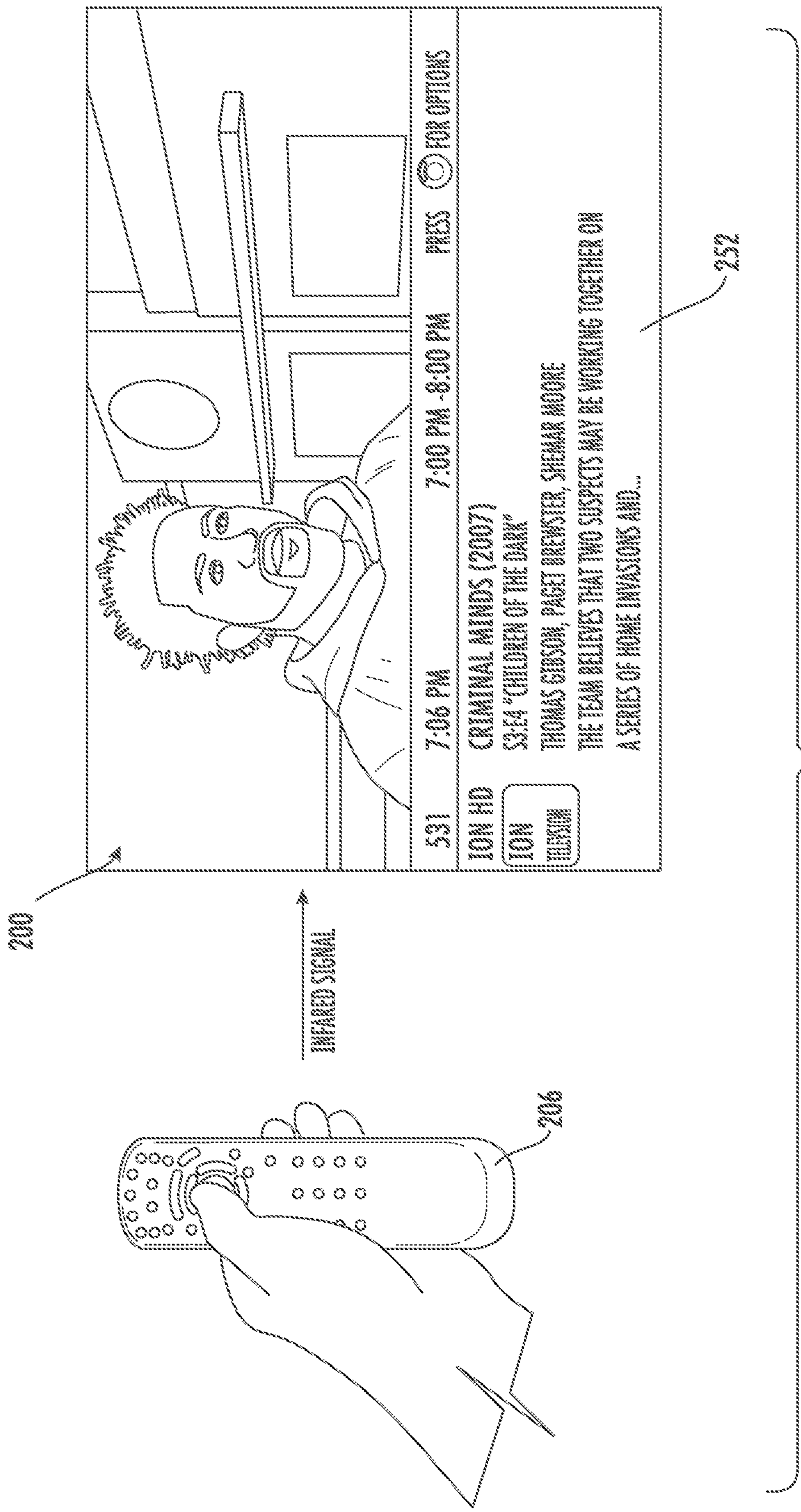

531
ION HD
7:06 PM
7:00 PM -8:00 PM
PRESS FOR OPTIONS
CRIMINAL MINDS (2007)
S3:E4 "CHILDREN OF THE DARK"
THOMAS GIBSON, PAGET BREWSTER, SHEMAR MOORE
THE TEAM BELIEVES THAT TWO SUSPECTS MAY BE WORKING TOGETHER ON
A SERIES OF HOME INVASIONS AND...
ION
252
200
INFARED SIGNAL
206

FIG. 10A

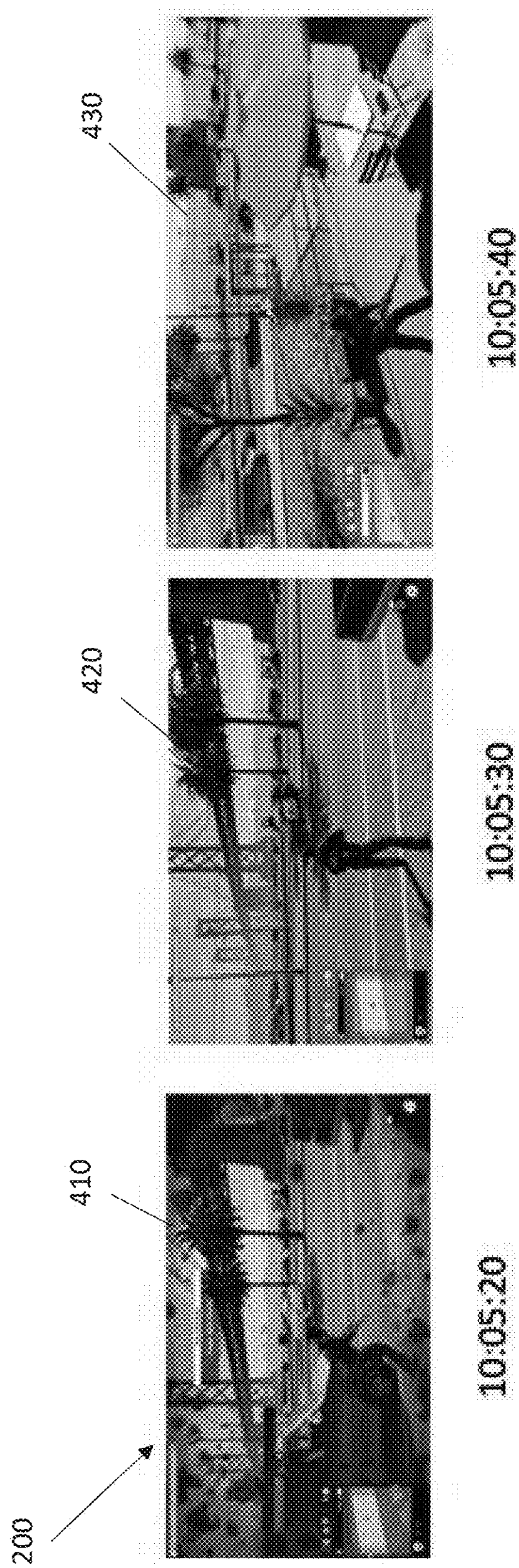


FIG. 10B

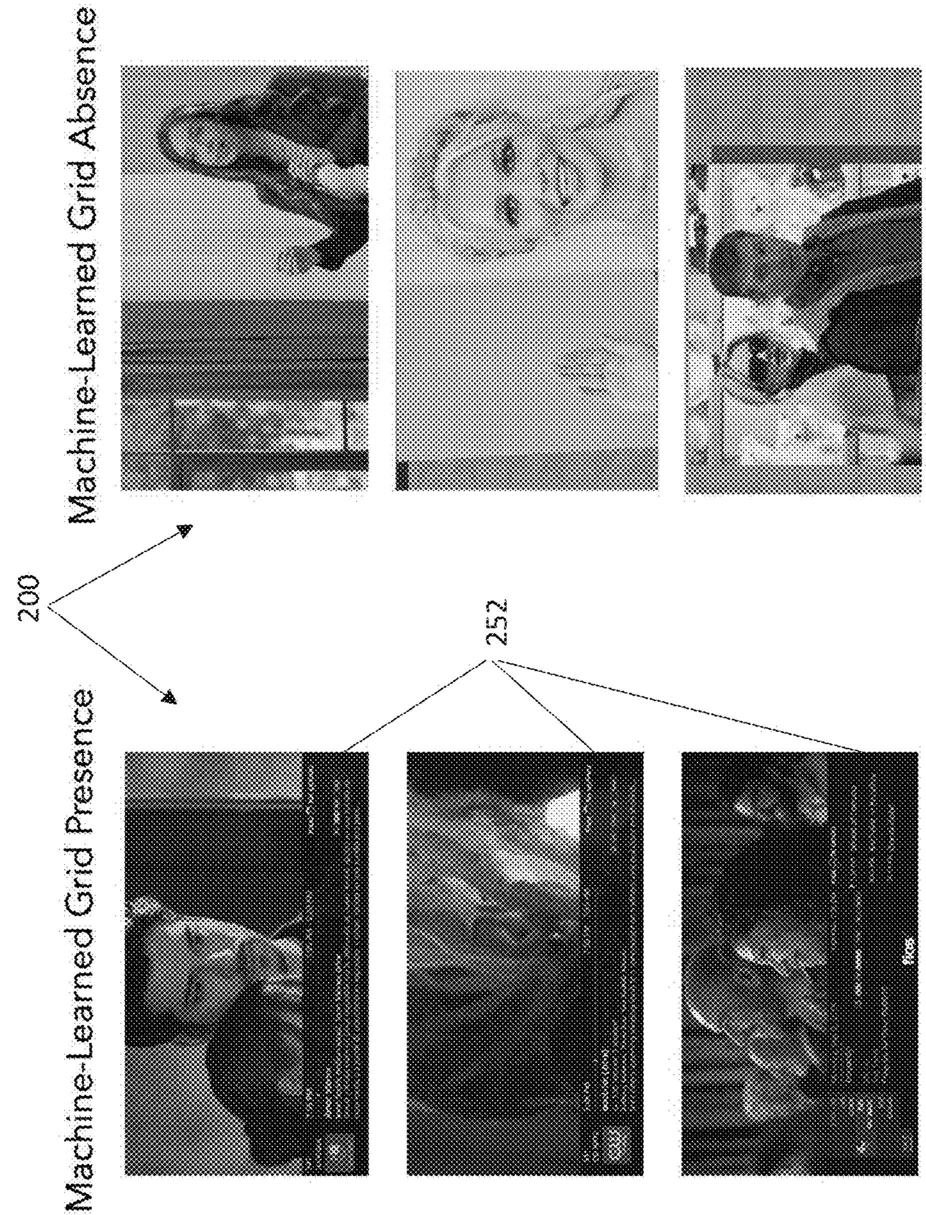

Machine-Learned Grid Absence
Machine-Learned Grid Presence
200
252

FIG. 10C

450

```
2020-06-12    19:06:13.196 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Waiting for TV-guide/grid appearance **        451
2020-06-12    19:06:13.265 5745-5745/com.personicore.hdmi1 I/MainActivity: ** TV-guide/grid detected. Analyzing ... **      452
2020-06-12    19:06:13.361 5745-5745/com.personicore.hdmi1 I/MainActivity: ** TV-guide/grid presence confirmed ... **       453
2020-06-12    19:06:14.024 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Extracting text from TV-guide/grid ... **     454
2020-06-12    19:06:14.120 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Extracting program: Criminal Minds (2007) **  455
2020-06-12    19:06:14.191 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Extracting network: ion HD **                 456
2020-06-12    19:06:14.263 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Extracting channel number: 531 ... **         457
2020-06-12    19:06:14.196 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Transmitting data to server ... **            458
2020-06-12    19:06:14.328 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Waiting for TV-guide/grid appearance **        459
```

FIG. 10D

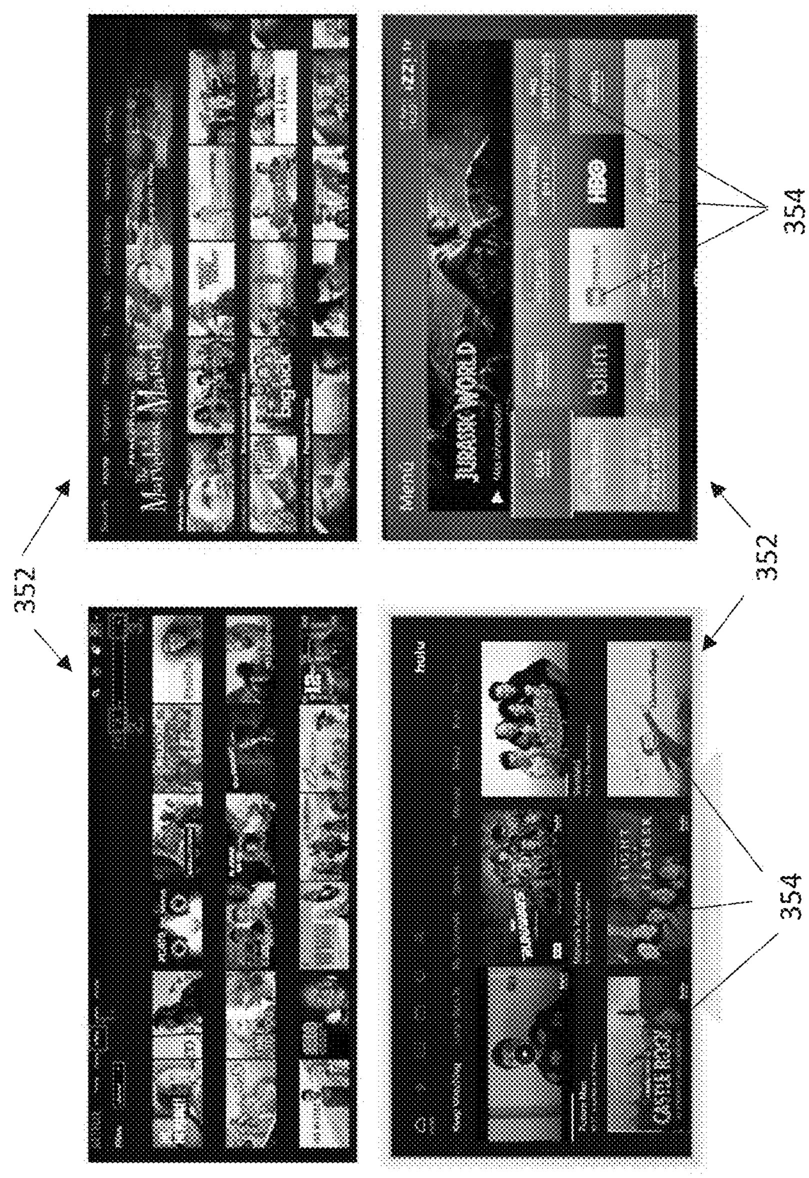


FIG. 10E

460

```
2020-06-12 20:05:18.014 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Waiting for content grid appearance ** 461
2020-06-12 20:05:18.111 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Content grid detected. Analyzing ... ** 462
2020-06-12 20:05:18.435 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Content grid presence confirmed ... ** 463
2020-06-12 20:06:19.216 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Extracting text from the content grid ... ** 464
2020-06-12 20:06:19.308 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Analyzing the selected option ... ** 465
2020-06-12 20:06:19.308 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Extracting text from selected option.... ** 466
2020-06-12 20:06:19.354 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Selected option: TV ** 467
2020-06-12 20:06:19.481 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Transmitting data to server ... ** 468
2020-06-12 20:06:19.495 5745-5745/com.personicore.hdmi3 I/MainActivity: ** Waiting for content grid appearance ** 469
```

FIG. 10F

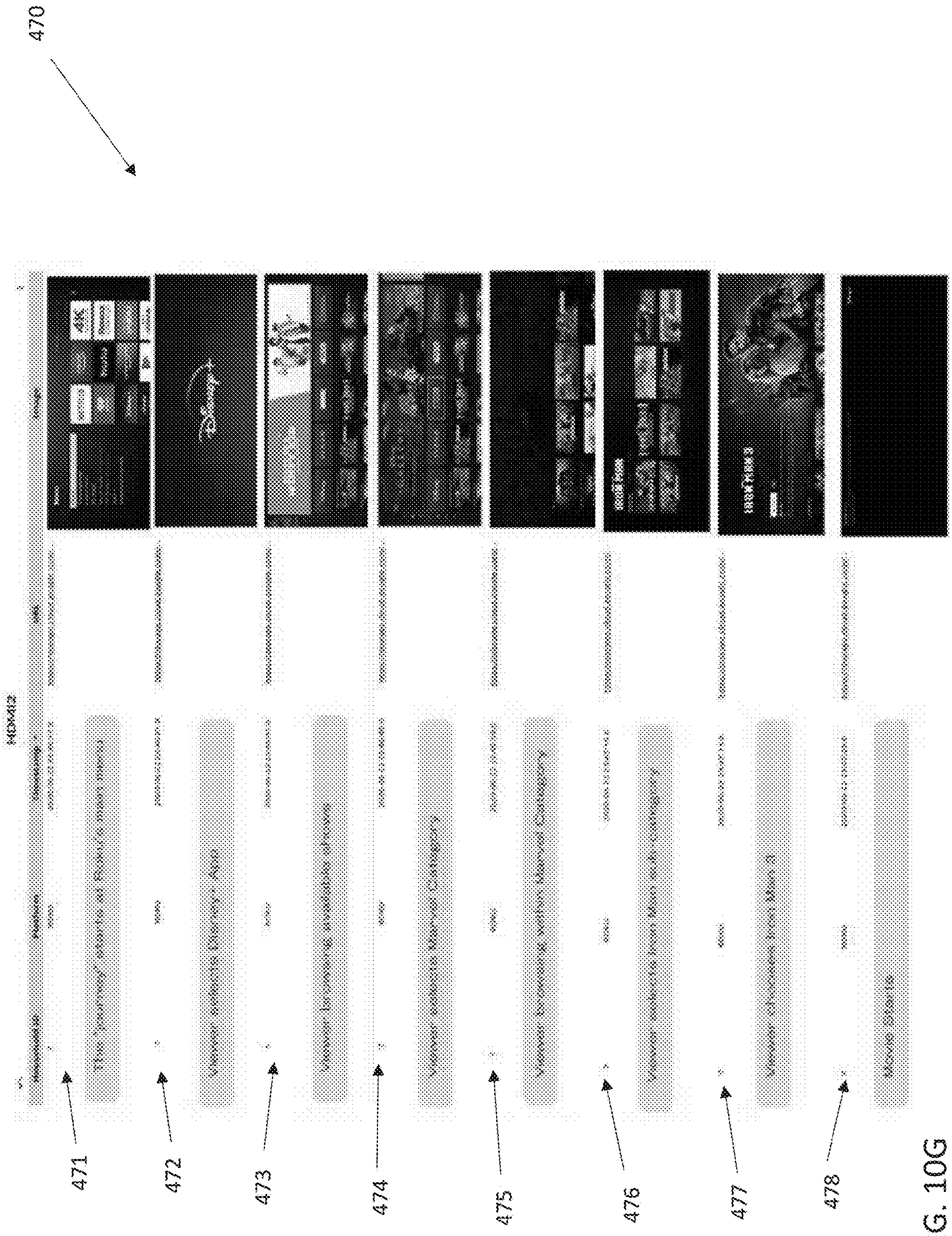
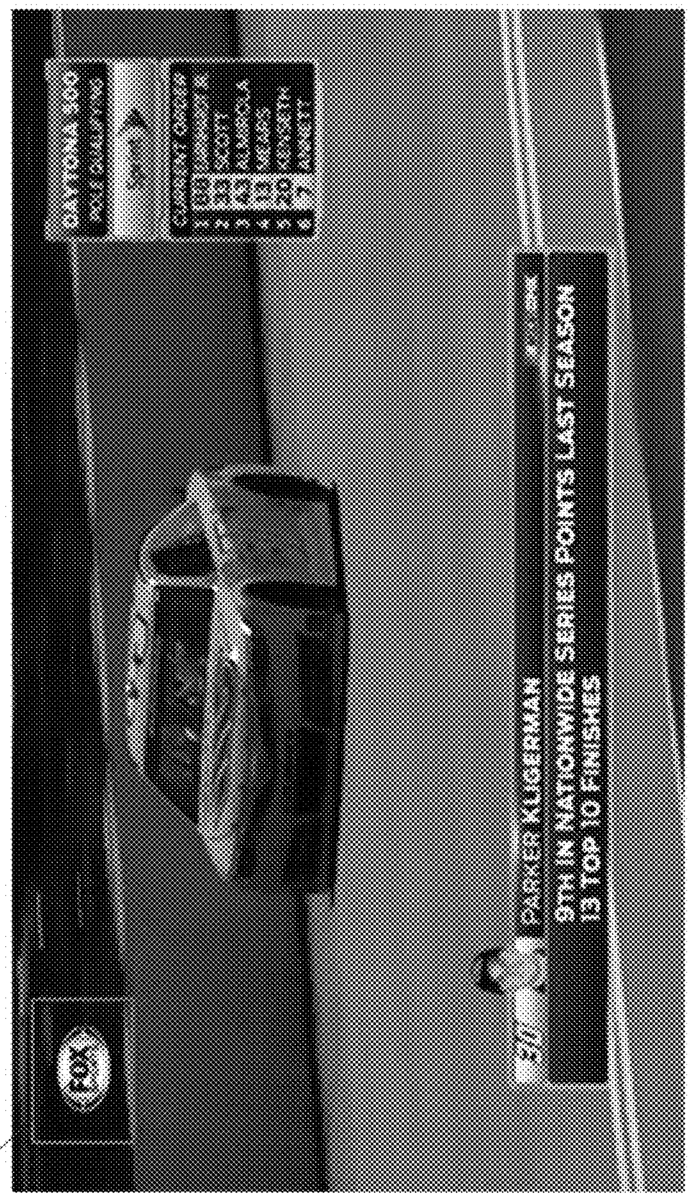


FIG. 10G

200



258

FIG. 10H

480

```
2020-06-16    07:35:13.046 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Detecting logo presence **
2020-06-16    07:35:13.189 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Network logo detected. Analyzing ... **
2020-06-16    07:35:14.180 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Logo recognized: FOX SPORTS **
2020-06-16    07:36:14.394 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Transmitting data to server ... **
2020-06-16    07:36:14.401 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Detecting logo presence **
2020-06-16    07:48:54.238 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Logo no longer present **
2020-06-16    07:48:54.394 5745-5745/com.personicore.hdmi1 I/MainActivity: ** Transmitting data to server ... **
```

481
482
483
484
485
486
487

Fig. 10I

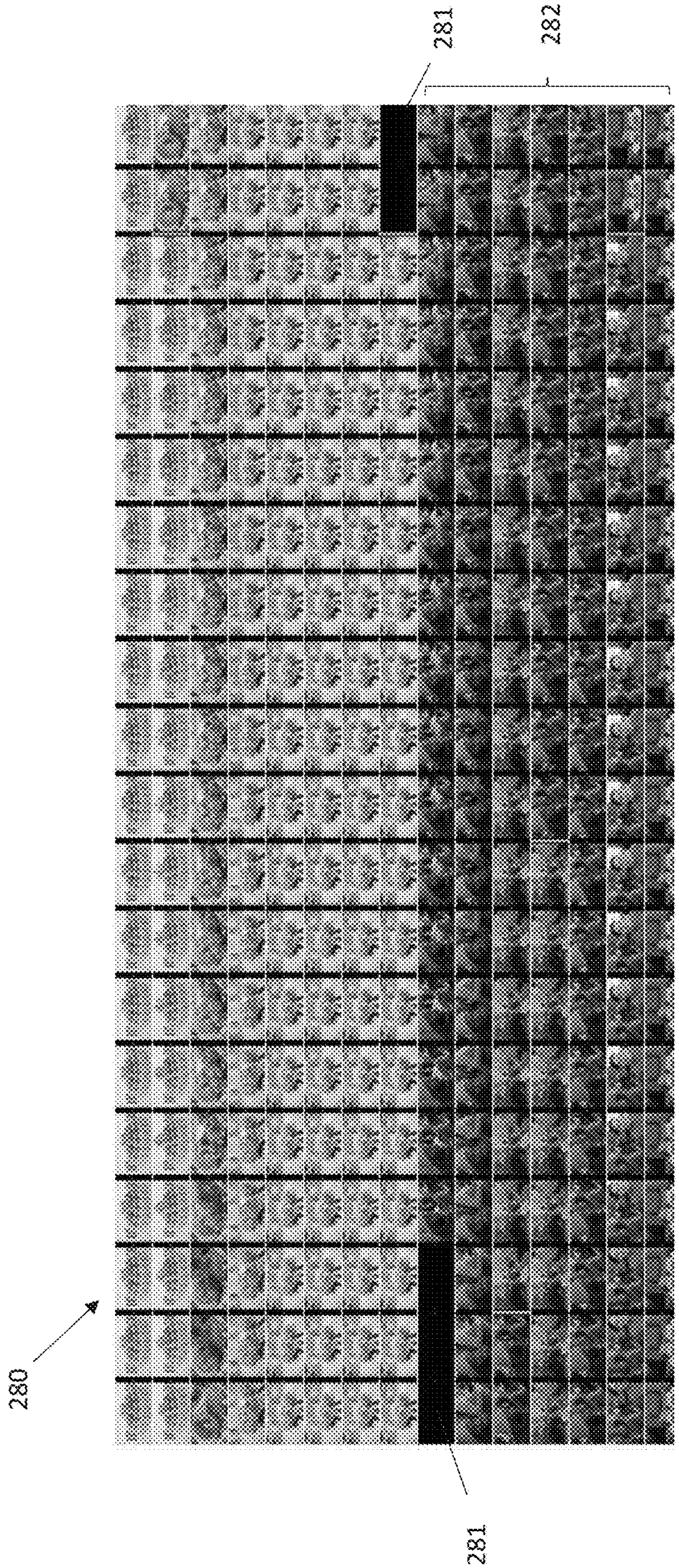


FIG. 10J

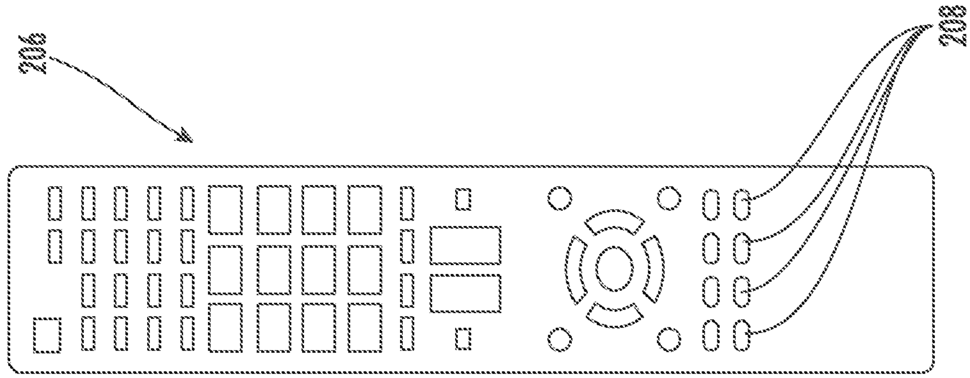


FIG. 11

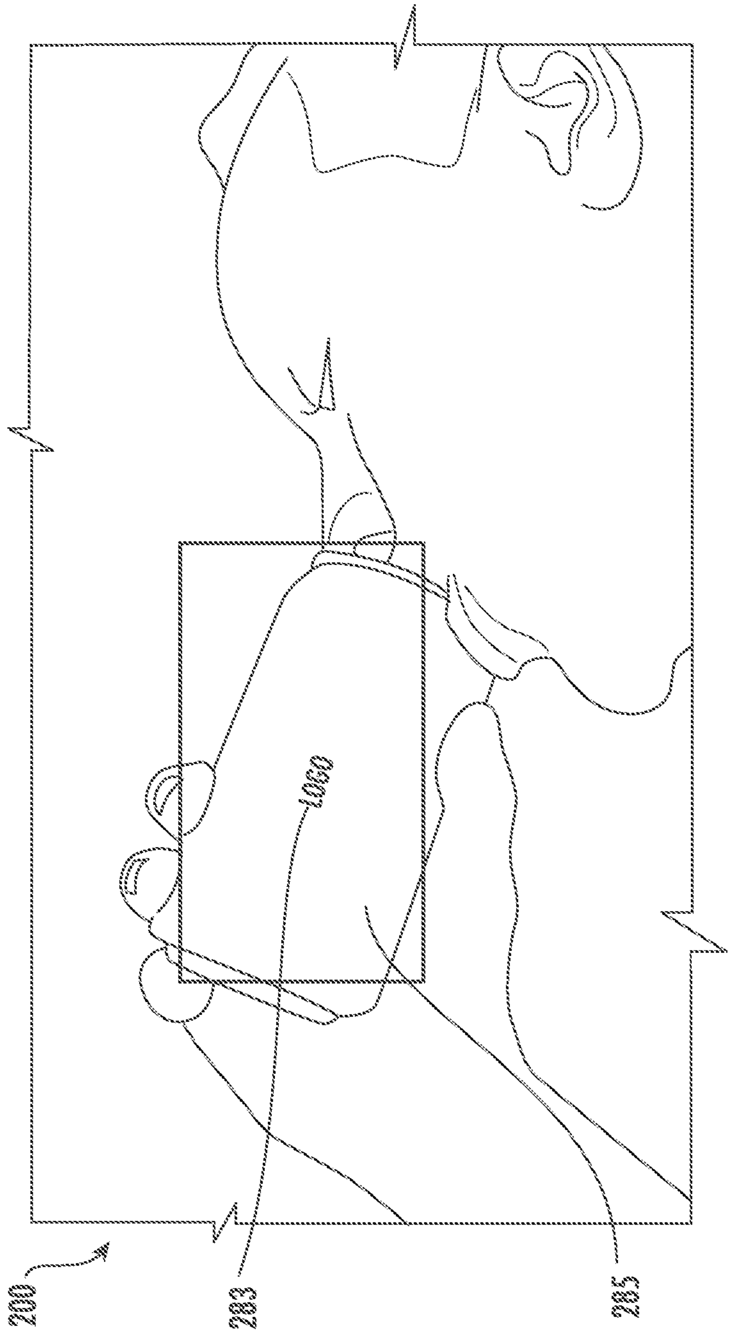


FIG. 10K

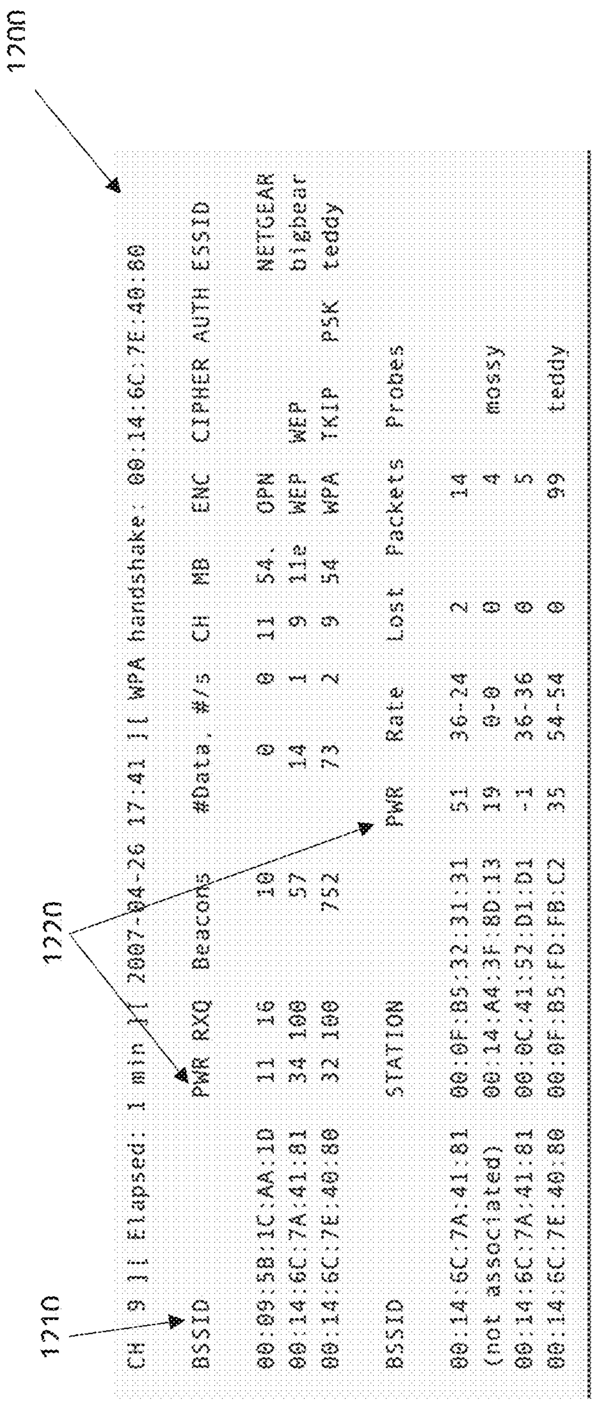

1200
1210
1220
CH 9][Elapsed: 1 min][2007-04-26 17:41][WPA handshake: 00:14:6C:7E:40:80
BSSID PWR RXQ Beacons #Data, #/s CH MB ENC CIPHER AUTH ESSID
00:09:5B:1C:AA:1D 11 16 10 0 0 11 54. OPN NETGEAR
00:14:6C:7A:41:81 34 100 57 14 1 9 11e WEP WEP bigbear
00:14:6C:7E:40:80 32 100 752 73 2 9 54 WPA TKIP PSK teddy
BSSID STATION PWR Rate Lost Packets Probes
00:14:6C:7A:41:81 00:0F:B5:32:31:31 51 36-24 2 14
(not associated) 00:14:A4:3F:8D:13 19 0-0 0 4 mossy
00:14:6C:7A:41:81 00:0C:41:52:D1:D1 -1 36-36 0 5
00:14:6C:7E:40:80 00:0F:B5:FD:FB:C2 35 54-54 0 99 teddy

FIG. 12

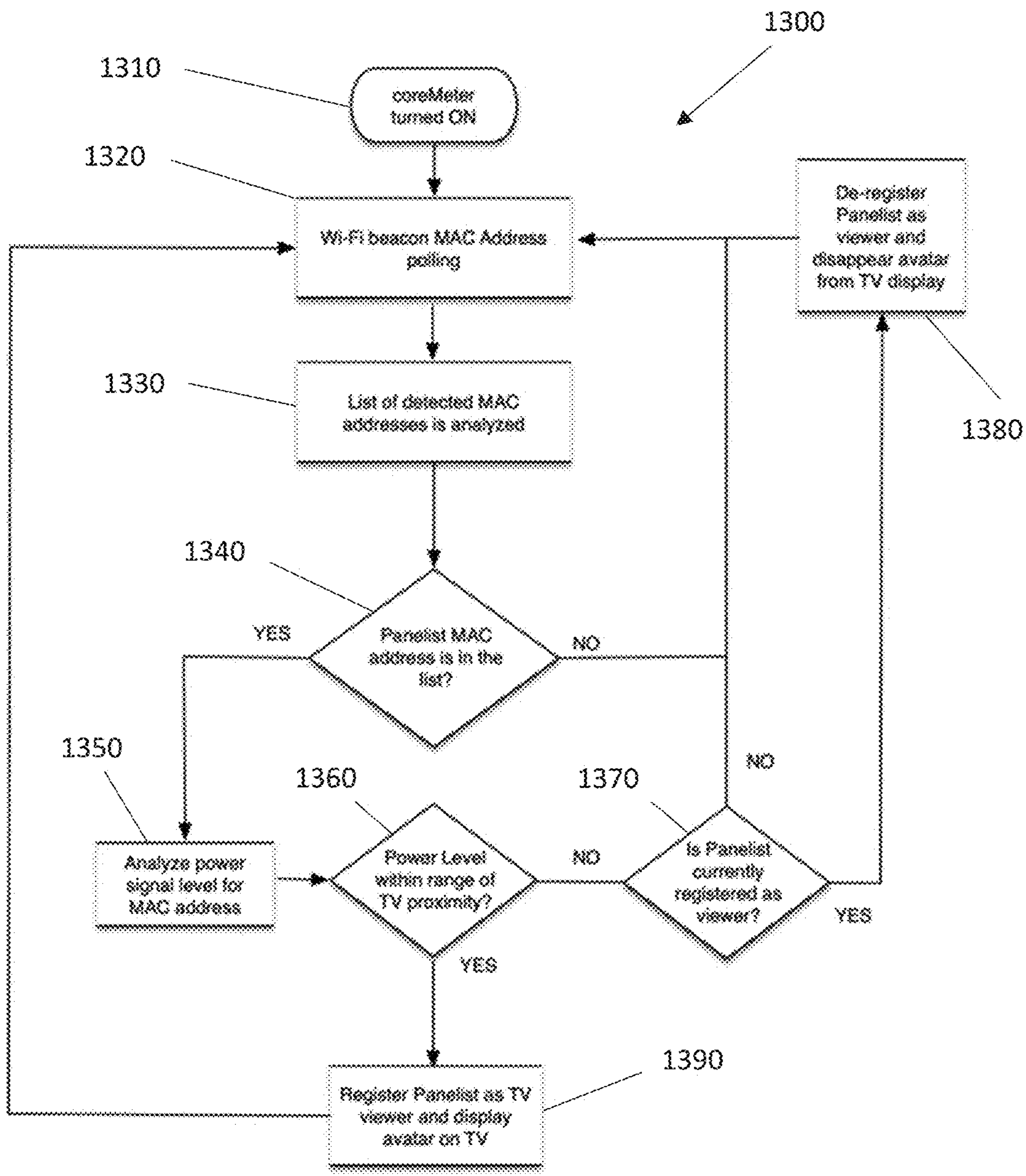

1300
1310
coreMeter turned ON
1320
Wi-Fi beacon MAC Address polling
1330
List of detected MAC addresses is analyzed
1340
Panelist MAC address is in the list?
YES
NO
De-register Panelist as viewer and disappear avatar from TV display
1380
1350
Analyze power signal level for MAC address
1360
Power Level within range of TV proximity?
NO
1370
Is Panelist currently registered as viewer?
NO
YES
YES
1390
Register Panelist as TV viewer and display avatar on TV

FIG. 13

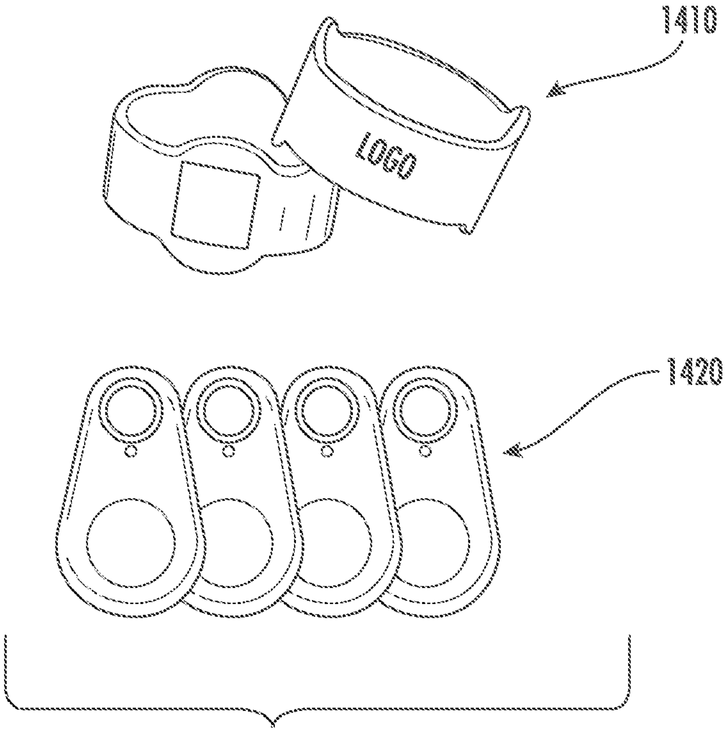


FIG. 14

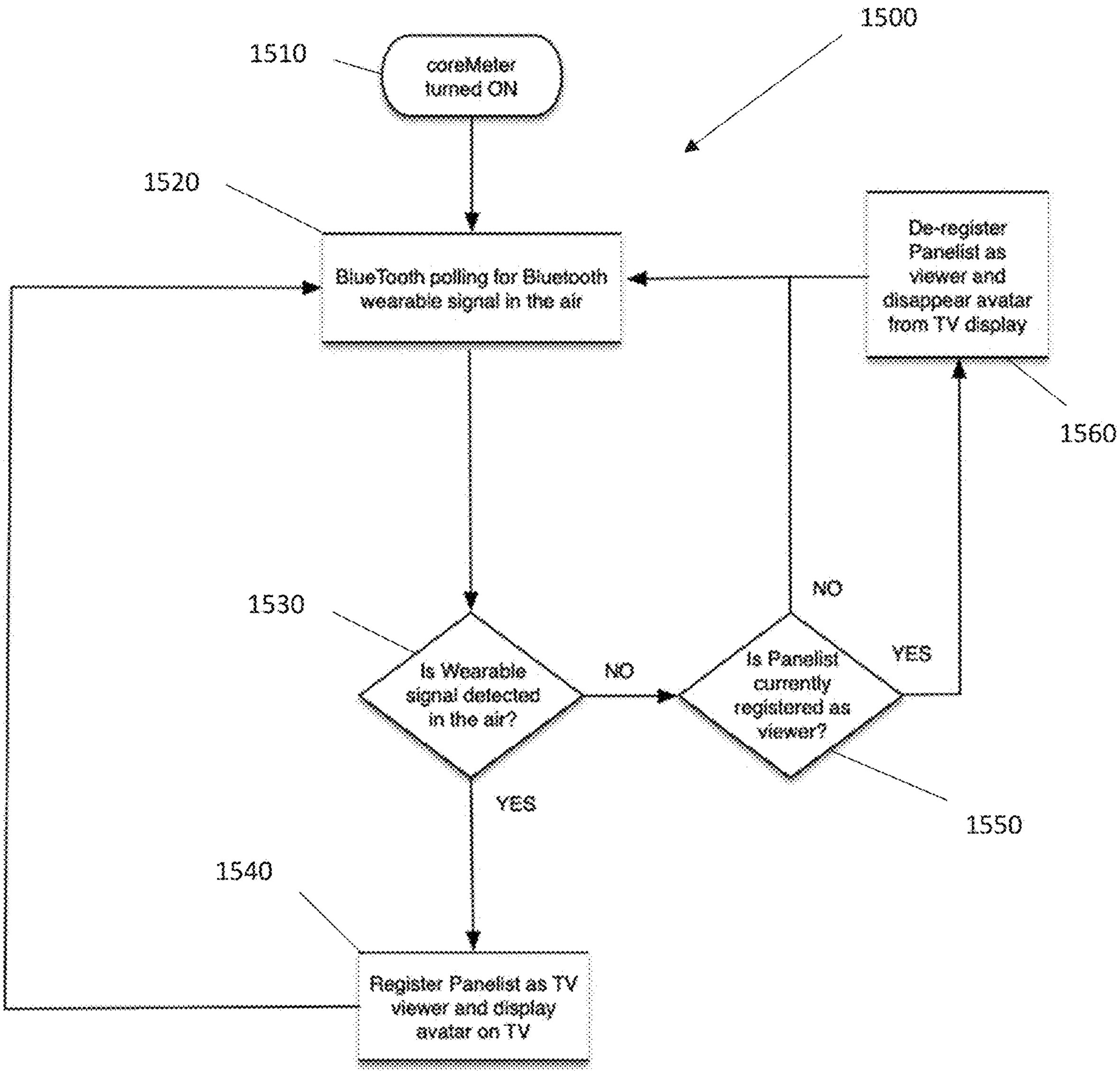

1500
1510
coreMeter turned ON
1520
BlueTooth polling for Bluetooth wearable signal in the air
De-register Panelist as viewer and disappear avatar from TV display
1560
1530
Is Wearable signal detected in the air?
NO
Is Panelist currently registered as viewer?
NO
YES
YES
1550
1540
Register Panelist as TV viewer and display avatar on TV

FIG. 15

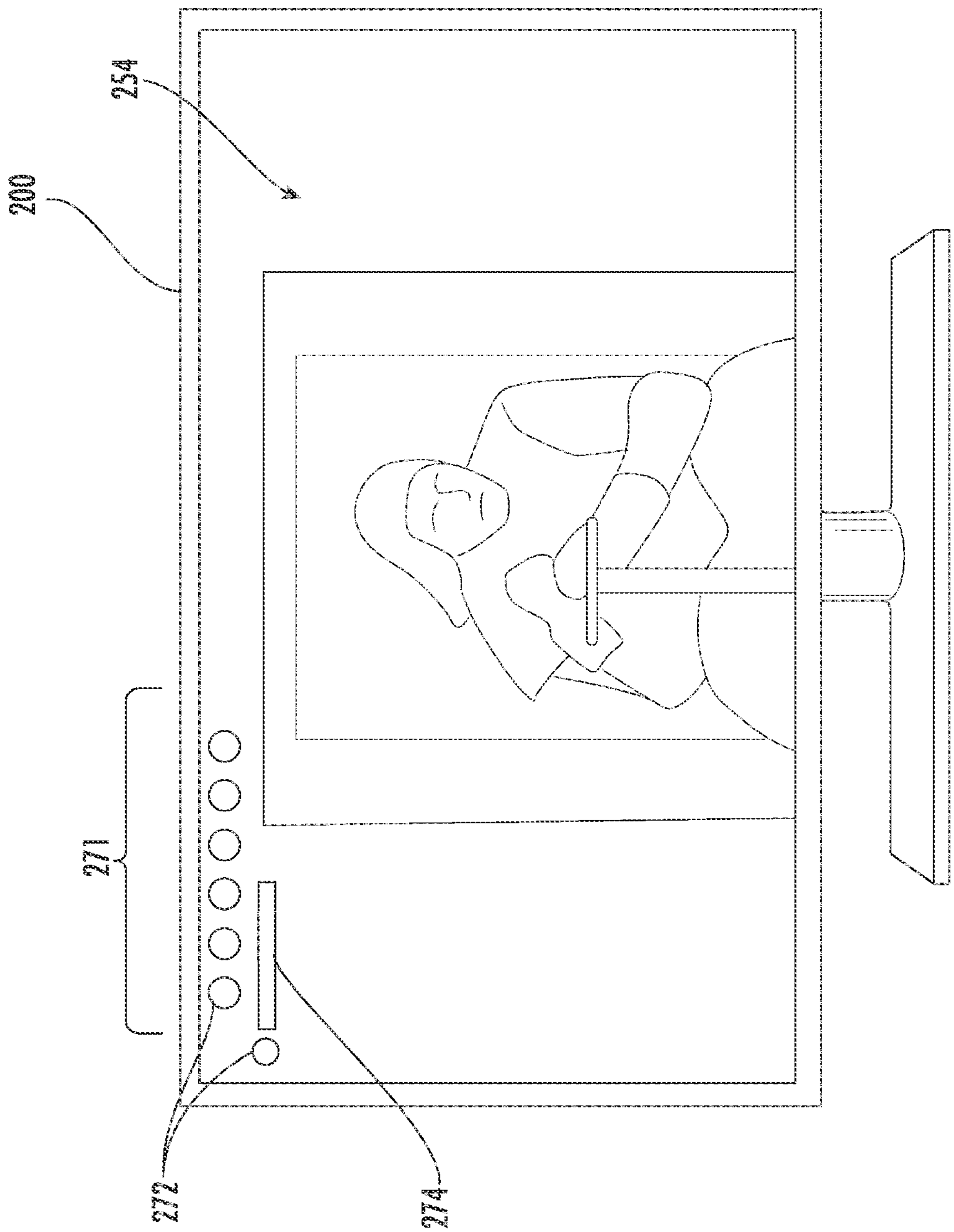


FIG. 16

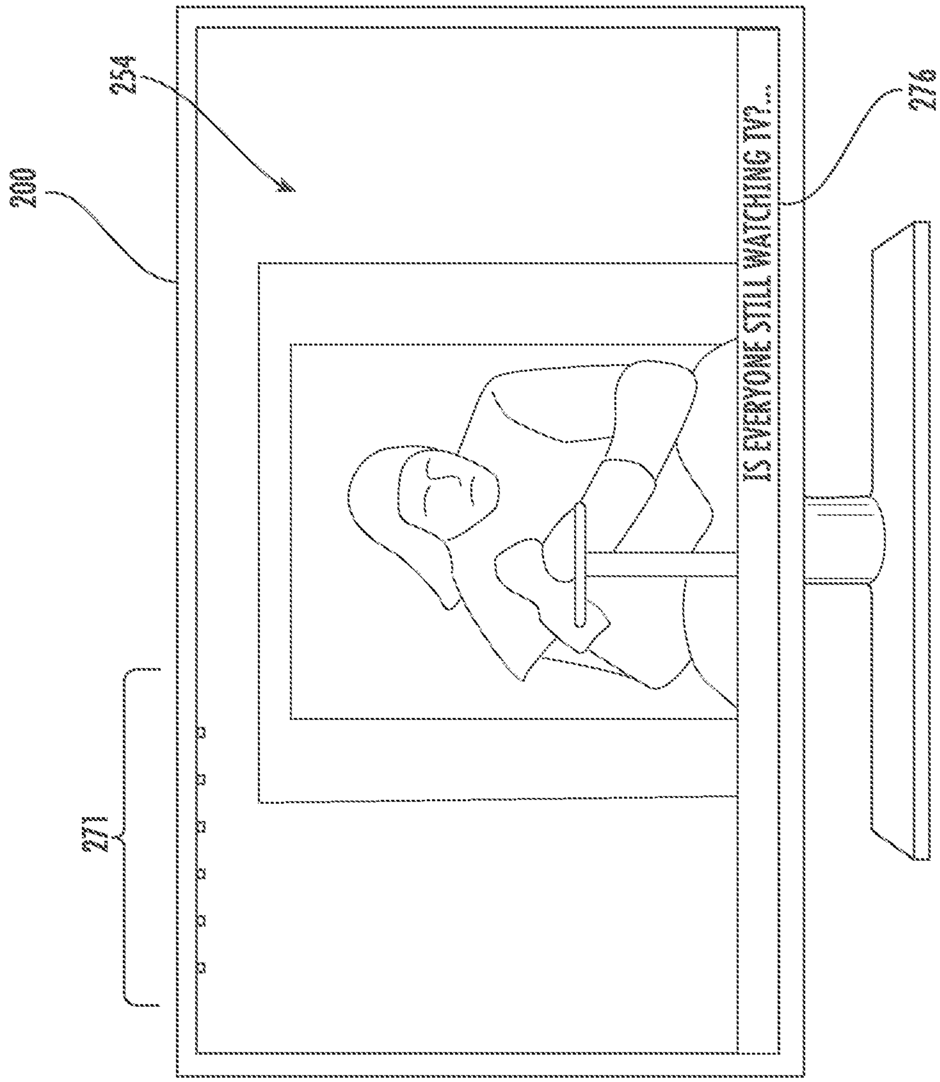


FIG. 17


1800
GET https://github.com/
← 200 text/html 5.52kB
GET https://a248.e.akamai.net/assets.github.com/stylesheets/bundles/github2-24f59e3ded11f2a
1c7ef9ee730882bd8d550cfb8.css
← 200 text/css 28.27kB
GET https://a248.e.akamai.net/assets.github.com/images/modules/header/logov7@4x-hover.png?1
334325424
← 200 image/png 6.01kB
GET https://a248.e.akamai.net/assets.github.com/javascripts/bundles/jquery-b2ca07cb3c906cec
cfd58811b430b8bc25245926.js
← 200 application/x-javascript 32.59kB
GET https://a248.e.akamai.net/assets.github.com/stylesheets/bundles/github-cb564c47c51a14
af1ae265d7ebab59c4e78b92cb.css
← 200 text/css 37.09kB
GET https://a248.e.akamai.net/assets.github.com/images/modules/home/logos/facebook.png?1334
526958
← 200 image/png 5.55kB
>> GET https://github.com/twitter
1810

FIG. 18

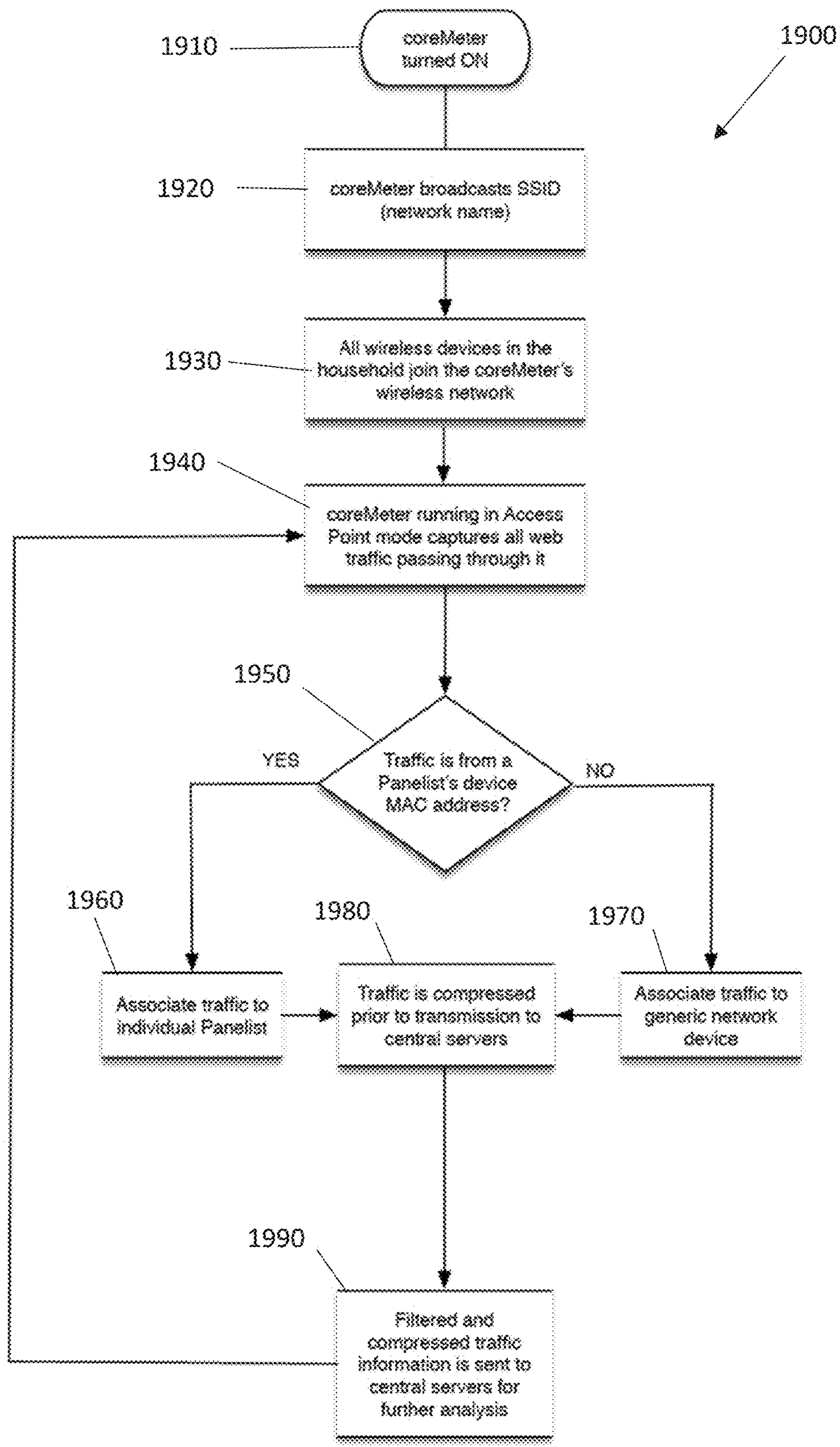

1900
1910
coreMeter turned ON
1920
coreMeter broadcasts SSID (network name)
1930
All wireless devices in the household join the coreMeter's wireless network
1940
coreMeter running in Access Point mode captures all web traffic passing through it
1950
Traffic is from a Panelist's device MAC address?
YES
NO
1960
Associate traffic to individual Panelist
1980
Traffic is compressed prior to transmission to central servers
1970
Associate traffic to generic network device
1990
Filtered and compressed traffic information is sent to central servers for further analysis

FIG. 19

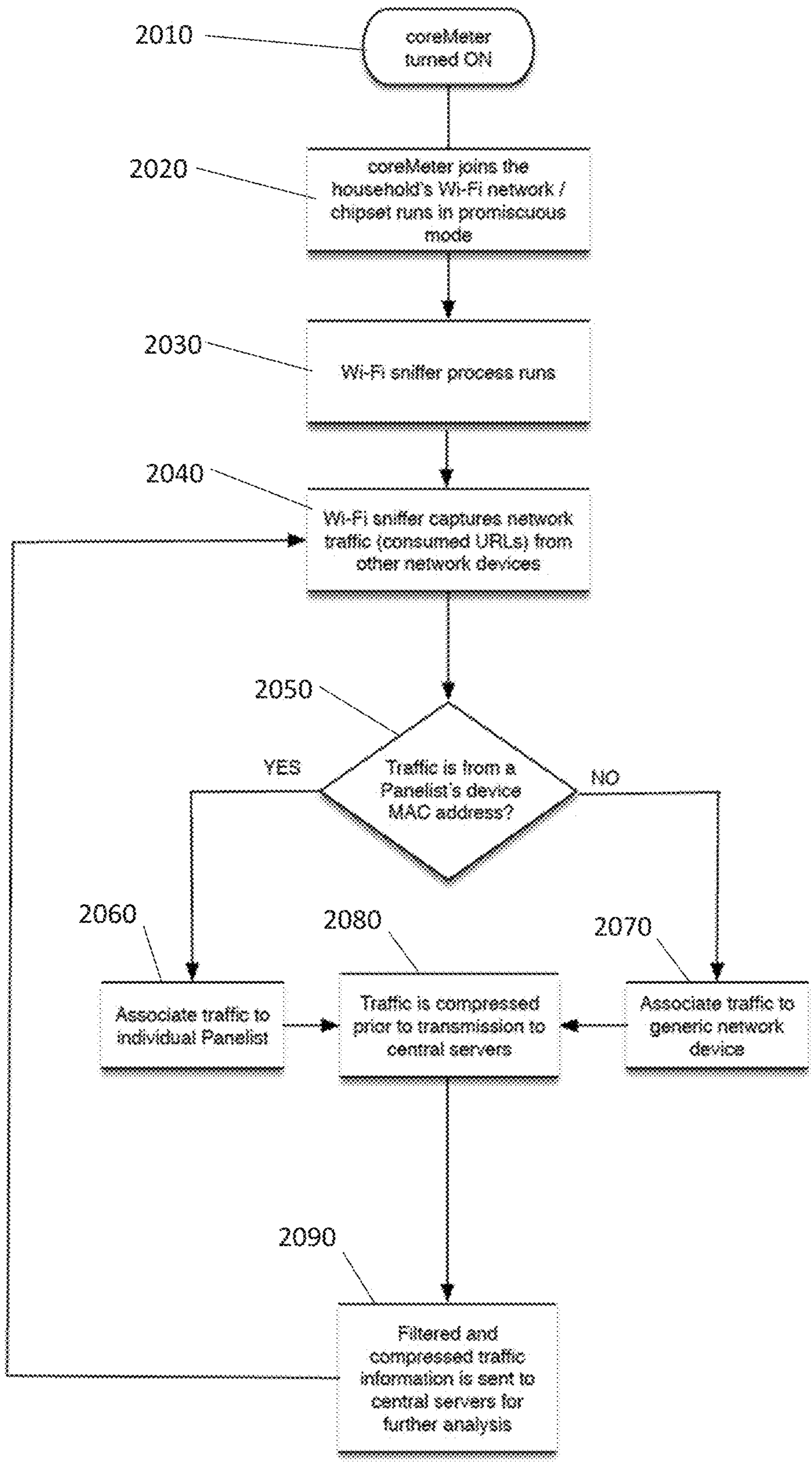

2010
coreMeter turned ON
2020
coreMeter joins the household's Wi-Fi network / chipset runs in promiscuous mode
2030
Wi-Fi sniffer process runs
2040
Wi-Fi sniffer captures network traffic (consumed URLs) from other network devices
2050
Traffic is from a Panelist's device MAC address?
YES
NO
2060
Associate traffic to individual Panelist
2080
Traffic is compressed prior to transmission to central servers
2070
Associate traffic to generic network device
2090
Filtered and compressed traffic information is sent to central servers for further analysis

FIG. 20

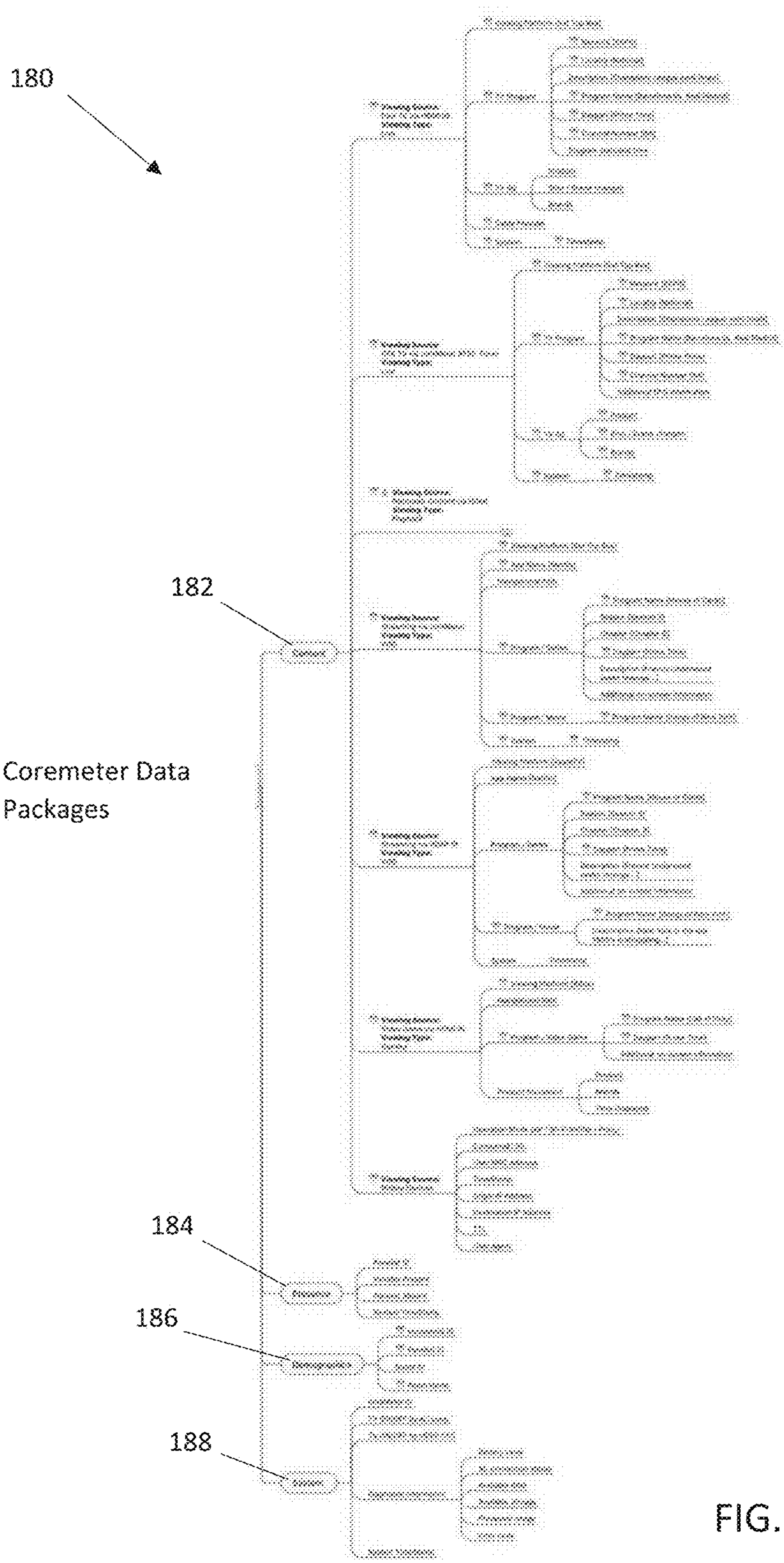


FIG. 21A

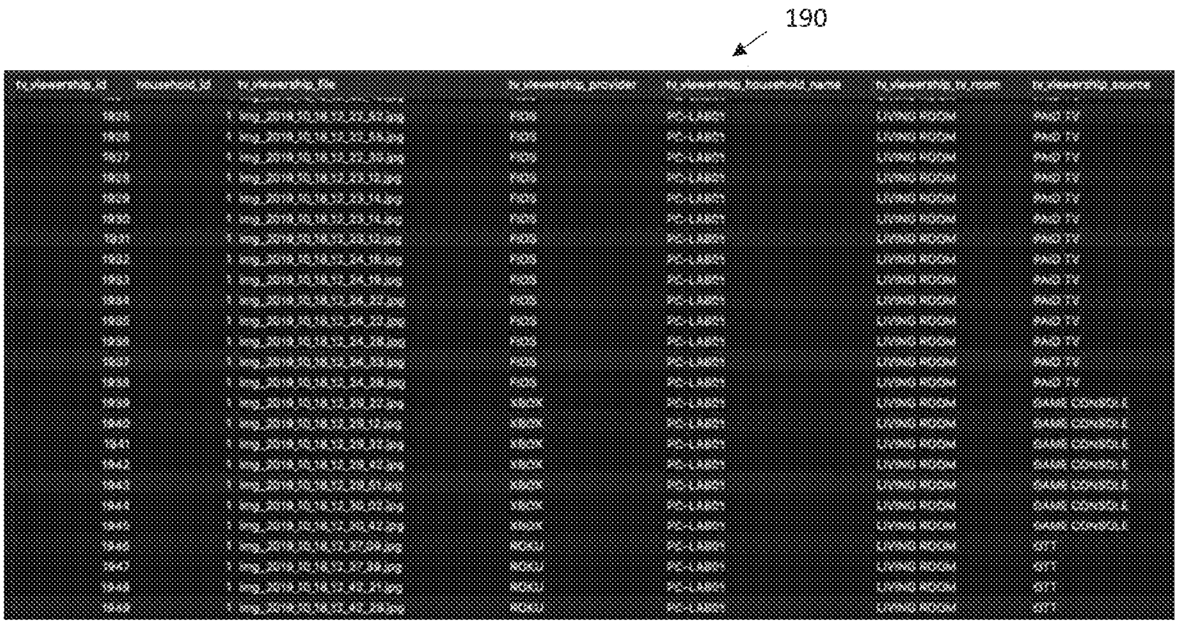


FIG. 21B

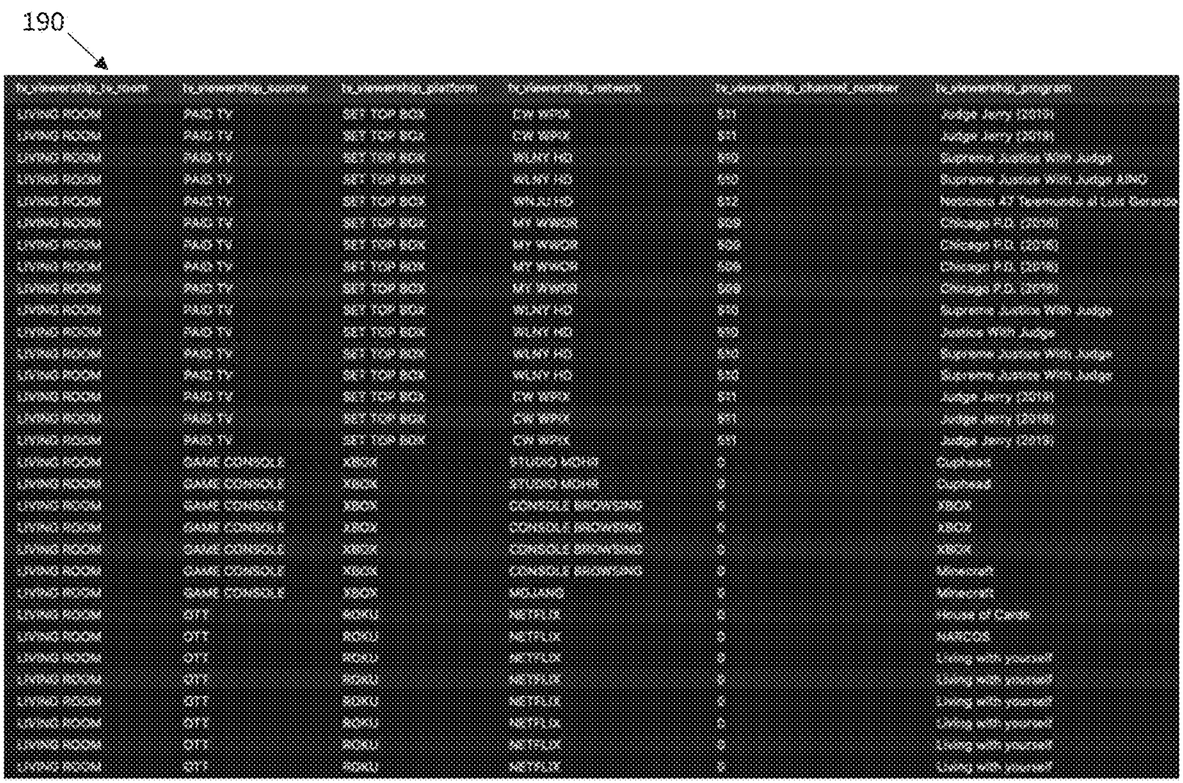
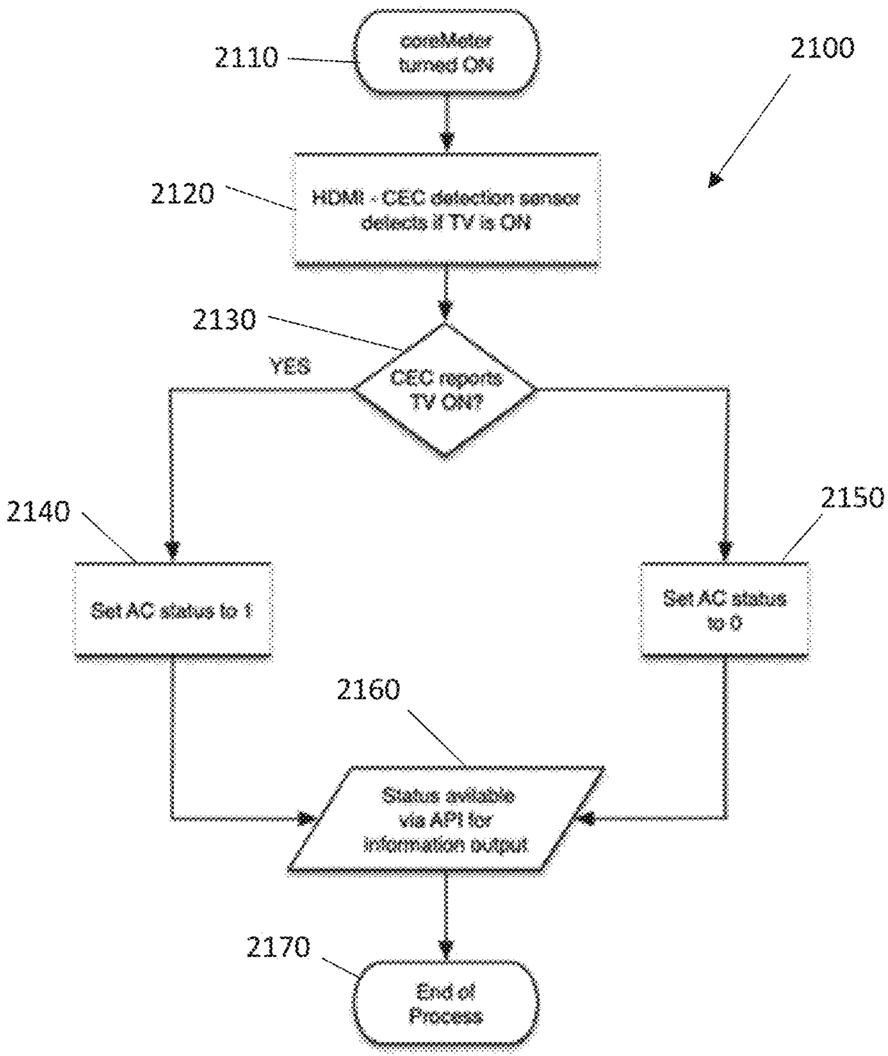


FIG. 21C



coreMeter turned ON
2110
2100
HDMI - CEC detection sensor detects if TV is ON
2120
CEC reports TV ON?
2130
YES
2140
Set AC status to 1
2150
Set AC status to 0
2160
Status avilable via API for information output
2170
End of Process

FIG. 22

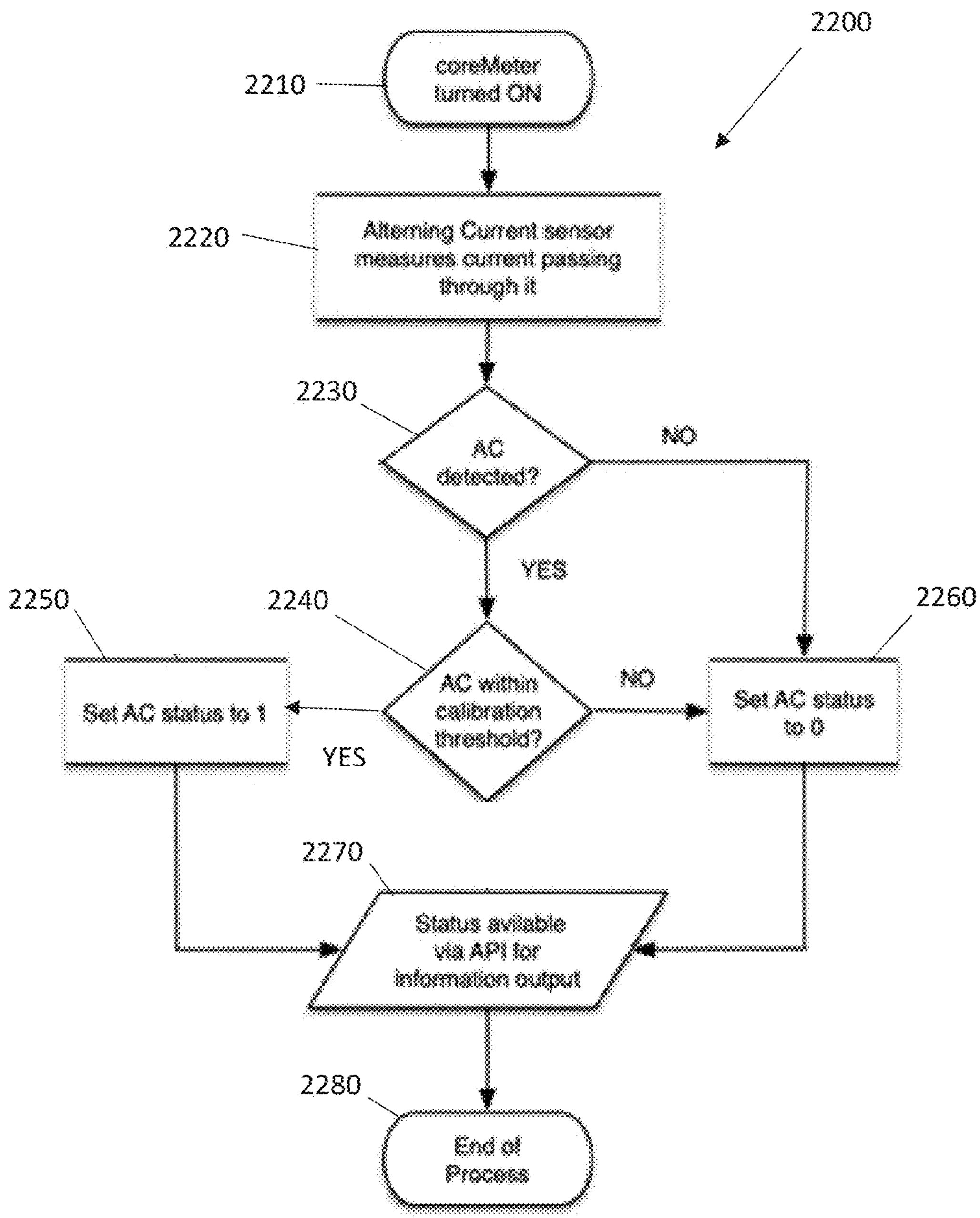

2200
2210
coreMeter turned ON
2220
Alterning Current sensor measures current passing through it
2230
AC detected?
NO
YES
2250
2240
2260
Set AC status to 1
AC within calibration threshold?
NO
Set AC status to 0
YES
2270
Status avilable via API for information output
2280
End of Process

FIG. 23

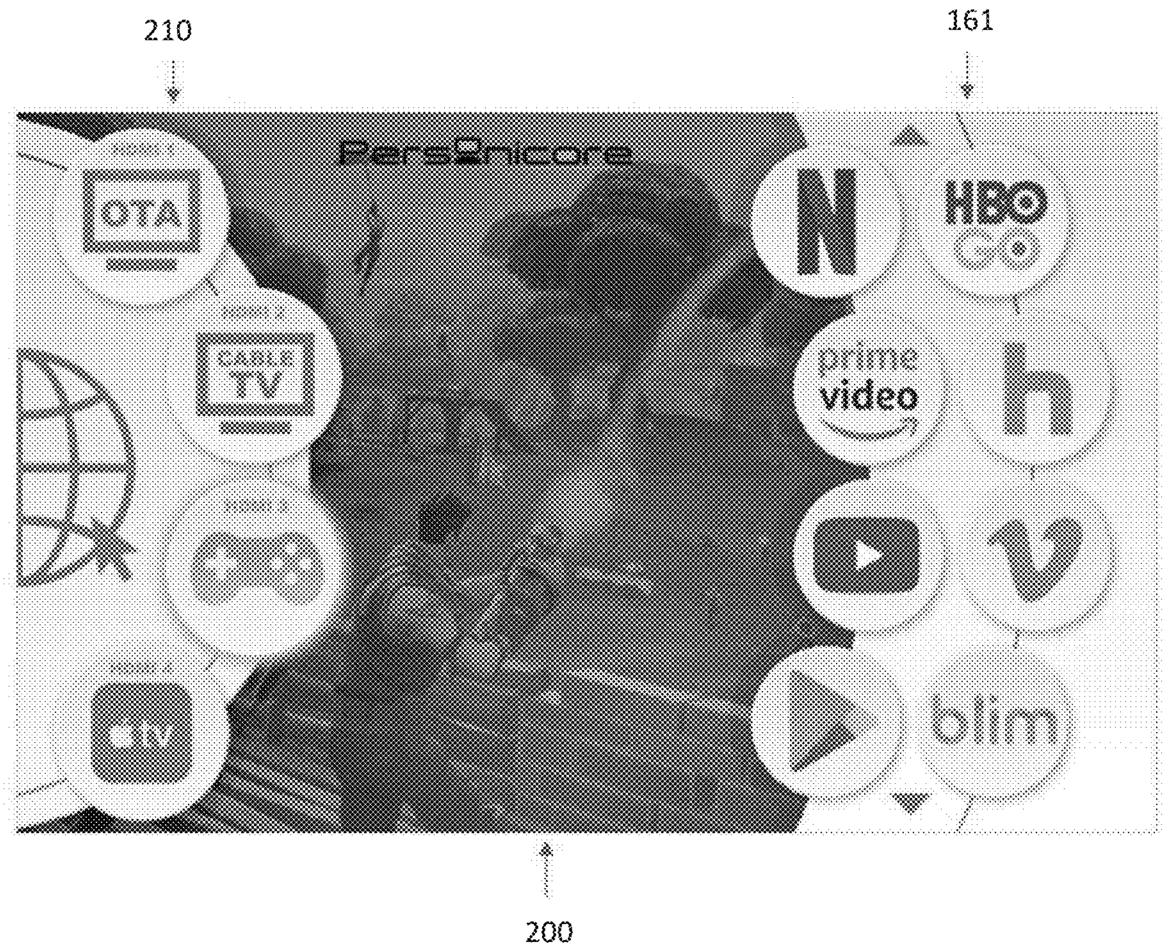


FIG. 24


210
161
200
OTA
CABLE TV
tv
NETFLIX
HBO GO
prime video
hulu
YouTube
vimeo
Google Play
blim

FIG. 25

CROSS-MEDIA MEASUREMENT DEVICE AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from U.S. Provisional Patent Application Ser. No. 62/871,789, filed Jul. 9, 2019, the entire contents of which are incorporated herein by reference.

FIELD

The present disclosure relates to the field of electronic media measurement, and particularly devices and methods for determining audience measurement for numerous media events.

BACKGROUND

Media content has been an important part of modern life for well over a century. Media content consumed in homes includes various sources, including cable television, over-the-air (OTA) television, recorded video (e.g., DVD), gaming consoles, and various internet sources offering media content via a high speed internet connection (i.e., over-the-top (OTT) content). While consumers enjoy the ability to watch this media content at will, media providers and advertisers have a vested interest in knowing exactly what media content is actually being consumed (i.e., media that is actually viewed, watched, or otherwise on a screen). By knowing this information, media providers and advertisers are better equipped to create new content and strategically place ads within such content.

The use of statistics offers one convenient approach to measuring media content consumption across a large population. To accomplish this, a group of households are recruited to serve on a "panel" intended to be representative of a larger population (e.g., the individuals in ten homes representative of a neighborhood, the individuals in one hundred homes representative of a city, etc.). Each household includes a number of individual panelists, and each panelist has specific demographic information (e.g., age, sex, ethnicity, income, etc.). By determining what media content that individual panelists are watching, statistical projections can be made about what media content is being consumed by the population as a whole.

For many years, the primary means for measuring media consumption by individuals within a household was the use of diaries. Each panelist was instructed them to keep a physical log of all content that they watched during the week. At the end of every day, each panelist would have a diary log listing everything the panelist watched for the day. This diary approach is still used in local markets to determine what ads to show during local news, etc. While the diary approach is capable of generating valuable information, there are many shortcomings. For example, panelists are notoriously inconsistent on accurately recording what they watched. Panelists often forget to log data, or simply cannot remember all of the media content they watched. The diary approach is also slow to assemble data, as physical diary logs must be collected from each user, the data compiled, and assembled into a user format. These activities not only take a significant amount of time and manpower, but are also subject to human error, making the diary approach to measuring media consumption costly and unreliable.

Numerous attempts have been made to implement technological solutions to the measurement of household media consumption in the hopes of addressing the shortcomings of diaries. Inaudible watermarks are an example of one such technological solution that has been attempted in the past. With this approach, audio signals that are inaudible to the human ear are incorporated into media content and captured by listening devices worn by the panelist. The watermark may be, for example, a series of inaudible tones, chimes, or other audio that are periodically played during television programs and/or advertisements. Each panelist is assigned a pager or other listening device that is worn on the panelist while at home. When the watermark is played, it is inaudible to the panelist, but the pager assigned to the panelist records the watermark, and a determination is made that the panelist was watching the media content at the time the watermark was played. Of course, the watermark approach also has numerous shortcomings. For example, media content is often not associated to a panelist because the panelist forgets to wear their pager, or the pager loses power. Also, media content is often incorrectly associated with a panelist because the panelist removes the pager from his or her person and subsequently leave the room. As a result, in accurate data is often collected by the pagers. Moreover, with the watermark approach, only content that includes a watermark is capable of being captured. Many types of media that a user enjoys may not have a watermark (e.g., non-participating programs and advertisements, DVDs and other recorded media, gaming systems, etc.). As a result, panelists may watch a significant amount of media that is not captured in any way by the system. Therefore, while watermark systems offer some benefits over the conventional diary approach, many deficiencies remain in these systems.

Another example of a past technological solution to measuring household media consumption is fingerprinting using various techniques such as audio or video "automatic content recognition" (ACR). Audio ACR involves recording all of the audio aired (either OTA or on cable TV) on various channels in order to provide a library of audio data within a database. The recorded audio include both programming and advertising. Data associated with each audio signal is also catalogued and saved to a programming grid that identifies all of the content played at different times on different channels. For example, for a particular program, information about the channel that aired the program, the time of airing, the actors in the program, title and other episode data may be catalogued and saved. Thereafter, audio ACR involves periodically recording a short clip of the audio signal (e.g., ten seconds) that is output from the television of the panelist. After an audio fingerprint is captured at a particular time, it is sent to the cloud and compared to each of the audio recordings in the library. When a match is found, i.e., when the fingerprint is matched to a particular portion of one of the audio recordings in the library, the media content is identified based on the grid. In this manner, audio ACR is capable of determining what aired content a user watched at any given time. However, because of difficulties with accurately collecting fingerprints for both programming and advertising, these libraries are generally separate, and either programming fingerprints or advertising fingerprints are captured for a single household, but not both.

Like other prior art solutions to measurement of household media consumption, audio ACR has numerous shortcomings. First, it will be quickly recognized that the computer resources required for audio ACR are enormous, including both the memory and processing power required to store massive amounts of audio content in the library and

subsequently compare each captured audio fingerprint to the audio content in the library. Similarly, the time required for system processors to actually compare each fingerprint to all audio recordings in the library is also significant. Moreover, the time and resources required to actually create the programming grid are also enormous. Audio ACR also has other shortcomings. For example, the audio signal captured by audio ACR is often noisy (e.g., because of noisy households), and incapable of recognition. Also, determining who was watching the identified content is problematic because users are required to actively register in association with the content (e.g., by pressing a button on the audio ACR device). Furthermore, audio ACR is only capable of identifying content that is associated with aired programs (i.e., either on cable or OTA). Audio ACR is incapable of identifying media content associated with gaming or OTT content. Audio ACR is also incapable of determining both programming and advertising consumption for a single household of panelists. Therefore, while audio ACR is capable of providing some advantages, it has numerous shortcomings that do not address the current needs in the industry.

Video ACR (also known as pixel ACR) is another form of ACR that operates similar to audio ACR, but monitors a video fingerprint instead of an audio fingerprint. In particular, video ACR records a number of pixels as a particular location on the screen, and then compares the recorded pixels to a library of pixels associated with programming and advertising content. While video ACR solves a few of the problems of audio ACR, such as noise associated with the audio signal, video ACR has related shortcomings. For example, video ACR is only capable of monitoring aired content associated with a particular time and channel. Video ACR is not capable of identifying content provided from other sources such as gaming consoles, video players (e.g., DVD players), or OTT content.

In view of the foregoing, it will be recognized that consumer's media viewing habits have far outpaced current measurement technology solutions which are unable to truly capture an audience's media exposure. The media consumption measurement industry is relying on multiple measurement sources for each device and relies on modeling to infer the measurement gaps. It would be advantageous to provide a system for media content measurement that is robust, capable of identifying content from all media sources within a household, and is not burdened by the shortcomings of past devices and methods for collecting and identifying consumed media content.

SUMMARY

In accordance with one exemplary embodiment of the disclosure, there is provided a method of identifying media content presented on a display device. The display device includes a screen and a speaker, and is in communication with a content gateway. The media content presented on the display device is provided by a video signal comprising a series of frames. The method comprises determining, at a processor within the gateway, a selected input source providing the video signal, wherein the selected input source is one of a plurality of input sources including at least a first input source and a second input source. The method further comprises selecting a first set of content identification rules when it is determined that the selected input source is the first input source, wherein the first set of content identification rules define a first trigger event and a first algorithm for analyzing one or more of the frames of the video signal following the first trigger event. Furthermore, the method comprises selecting a second set of content identification rules when it is determined that the selected input source is the second input source, wherein the second set of content identification rules define a second trigger event and a second algorithm for analyzing one or more frames of the video signal following the second trigger event, and wherein the second set of content identification rules is different from the first set of content identification rules. Additionally, the method comprises applying the selected first set or second set of content identification rules to the video signal in order to generate content identification data for the media content presented on the display device, wherein applying the selected first set of content identification rules includes waiting for the first trigger event and applying the first algorithm to one or more frames of the video signal following the first trigger event, and wherein applying the selected second set of content identification rules includes waiting for the second trigger event and applying the second algorithm to one or more frames of the video signal following the second trigger event.

In accordance with another exemplary embodiment of the disclosure, a non-transitory computer-readable medium is disclosed for identifying media content provided by a video signal delivered to and presented on a display device. The computer-readable medium includes a plurality of instructions stored thereon that, when executed by a processor, cause the processor to determine a selected input source providing the video signal, wherein the selected input source is one of a plurality of input sources including at least a first input source and a second input source. The instructions further cause the processor to select a first set of content identification rules when it is determined that the selected input source is the first input source, wherein the first set of content identification rules define a first trigger event and a first algorithm for analyzing one or more frames of the video signal following the first trigger event. The instructions also cause the processor to select a second set of content identification rules when it is determined that the selected input source is the second input source, wherein the second set of content identification rules define a second trigger event and a second algorithm for analyzing one or more frames of the video signal following the second trigger event, the second set of content identification rules being different from the first set of content identification rules. Additionally, the instructions cause the processor to apply the selected first set or second set of content identification rules to the video signal in order to generate content identification data for the media content presented on the display device, wherein application of the selected first set of content identification rules causes the processor to wait for the first trigger event and apply the first algorithm to one or more frames of the video signal following the first trigger event, and wherein application of the selected second set of content identification rules causes the processor to wait for the second trigger event and applying the second algorithm to one or more frames of the video signal following the second trigger event.

In accordance with yet another exemplary embodiment of the disclosure there is presented a gateway for identifying media content presented on a display device including a screen and a speaker. The gateway includes a plurality of input ports, an output port, and a processor. The plurality of input ports include at least a first input port and a second input port. The output port is configured to transfer a video signal received at the first input port or the second input port to the display device, wherein the video signal includes a series of frames that provide the media content. The pro-

cessor is configured to execute a computer application comprising a plurality of instructions which are configured to, when executed, cause the gateway to determine a selected input port providing the video signal, and select a first set of content identification rules when it is determined that the selected input port is the first input port, wherein the first set of content identification rules define a first trigger event and a first algorithm for analyzing one or more frames of the video signal following the first trigger event. The instructions further cause the gateway to select a second set of content identification rules when it is determined that the selected input port is the second input port, wherein the second set of content identification rules define a second trigger event and a second algorithm for analyzing one or more frames of the video signal following the second trigger event, and wherein the second set of content identification rules is different from the first set of content identification rules. Additionally, the instructions cause the gateway to apply the selected first set or second set of content identification rules to the video signal in order to generate content identification data for the media content presented on the display device, wherein application of the selected first set of content identification rules causes the processor to wait for the first trigger event and apply the first algorithm to one or more frames of the video signal following the first trigger event, and wherein application of the selected second set of content identification rules causes the processor to wait for the second trigger event and apply the second algorithm to one or more frames of the video signal following the second trigger event.

The above described features and advantages, as well as others, will become more readily apparent to those of ordinary skill in the art by reference to the following detailed description and accompanying drawings. While it would be desirable to provide a method and system for media measurement that provides one or more of these or other advantageous features as may be apparent to those reviewing this disclosure, the teachings disclosed herein extend to those embodiments which fall within the scope of any eventually appended claims, regardless of whether they include or accomplish one or more of the advantages or features mentioned herein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a diagram of a system for cross-media content measurement including a media content gateway positioned within a household and in communication with a remote server;

FIG. **2**A shows a block diagram of the gateway of FIG. **1**;

FIG. **2**B shows a schematic arrangement for the electronic components within the gateway of FIG. **1**;

FIG. **2**C shows a perspective view of one embodiment of a housing for the gateway of FIG. **1**;

FIG. **2**D shows a perspective view of an alternative embodiment of a housing for the gateway of FIG. **1**;

FIG. **3** shows a block diagram of the remote server of FIG. **1**;

FIG. **4** shows inclusion of the gateway of FIG. **1** in an entertainment center of a household along with various other media components;

FIG. **5**A shows a first flowchart of general operation of the gateway of FIG. **1**;

FIG. **5**B shows a second flowchart of general operation of the gateway of FIG. **1**;

FIG. **5**B**1** shows a flowchart of implementation of a first set of content identification rules when a selected input source is OTA television;

FIG. **5**B**2** shows FIG. **5**B**1** shows a flowchart of implementation of a second set of content identification rules when a selected input source is a set-top box;

FIG. **5**B**3** shows a flowchart of implementation of a third set of content identification rules when a selected input source is OTT content;

FIG. **5**B**4** shows a flowchart of implementation of a fourth set of content identification rules when a selected input source is a disc player or a video game console;

FIG. **6** shows an illustration of content identified via the gateway of FIG. **1** from a household of exemplary panelists;

FIG. **7** illustrates a dataset of media consumption data for a panel collected at the remote server of FIG. **1**;

FIG. **8** is a diagram showing exemplary inputs into the gateway of FIG. **1** and an associated HDMI output to the television;

FIG. **9** shows an example of media content presented on a television and metadata extracted from a frame of the content;

FIG. **10**A illustrates an infrared trigger event used in association with a set of content identification rules in the gateway of FIG. **1**;

FIG. **10**B is illustrates a time based trigger event used in association with the gateway of FIG. **1**;

FIG. **10**C illustrates several content banners displayed on the television of FIG. **1**;

FIG. **10**D is an exemplary content log illustrating use of the content banner of FIG. **10**C as a trigger event;

FIG. **10**E illustrates several content mosaics displayed on the television of FIG. **1**;

FIG. **10**F is an exemplary content log illustrating use of the content mosaic of FIG. **10**E as a trigger event;

FIG. **10**G is an exemplary content log illustrating a user's path through one of the content mosaics of FIG. **10**E;

FIG. **10**H illustrates a network logo displayed on the television of FIG. **1**;

FIG. **10**I is an exemplary content log illustrating use of the network logo of FIG. **10**H as a trigger event;

FIG. **10**J illustrates a trigger event provided by a scene change within a series of video frames;

FIG. **10**K illustrates a brand recognition trigger event used in association with the gateway of FIG. **1**;

FIG. **11** is a plan view of an exemplary remote control for the gateway of FIG. **1**;

FIG. **12** is a table of Wi-Fi handshake information collected at the gateway of FIG. **1**;

FIG. **13** is a flowchart of a method for registering and de-registering panelists at the gateway based on a Wi-Fi signal strength detected at the gateway of FIG. **1**;

FIG. **14** shows a perspective view of exemplary wearable electronic devices for use with panelist registration to the gateway of FIG. **1**;

FIG. **15** is a flowchart of a method for registering and de-registering panelists at the gateway based on a Bluetooth communications with a wearable electronic device at the gateway of FIG. **1**;

FIG. **16** is an exemplary television with media content presented on the screen and registered panelists displayed as avatars on the screen according to the method of FIG. **15**;

FIG. **17** shows the exemplary television of FIG. **16** when the avatars are muted on the screen;

FIG. **18** shows an exemplary network traffic log when the gateway of FIG. **1** operates in a router mode.

FIG. **19** is a flowchart of a method for detecting network traffic when the gateway of FIG. **1** operates in the router mode;

FIG. **20** is a flowchart of a method for detecting network traffic when the gateway of FIG. **1** operates in a promiscuous mode;

FIG. **21**A is a tree diagram of exemplary data packages generated by the gateway of FIG. **1** based on different rule sets for different input sources;

FIG. **21**B illustrates a database having exemplary data associated with the data packages of FIG. **21**A;

FIG. **21**C illustrates additional data within the database of FIG. **21**B;

FIG. **22** is a flowchart of a method of determining television on/off state using HDMI-CEC detection at the HDMI output port of the gateway of FIG. **1**;

FIG. **23** is a flowchart of a method of determining television on/off state using the AC power detection circuit in the gateway of FIG. **1**;

FIG. **24** is a first exemplary embodiment of a graphical user interface for the gateway of FIG. **1**; and

FIG. **25** is a second exemplary embodiment of a graphical user interface for the gateway of FIG. **1**.

DESCRIPTION

A system and method for cross-media content measurement is disclosed herein. As shown in FIG. **1**, the system for cross-media measurement **100** includes a media gateway **110** connected to a television **200** or other display device within a household. The gateway **110** is connected to various media sources within a household **202**, including both wired media sources **210** and wireless media devices **220**. The gateway **110** is configured detect consumption of and identify media content presented on both the television **200** and the various wireless devices **220**. The gateway **110** is further configured to associate one or more panelists **204** with the identified media content. Data collected by the gateway **110** is transmitted to a remote server **310** via the internet **290** or other wide area network. The remote server **310** may perform additional processing on the data collected by the gateway **110** in order to determine the specific media content consumed by each of the specific panelists.

Gateway Architecture

FIGS. **2A-2C** show an exemplary embodiment of the media gateway **110** (which may also be referred to as a "content recognition meter" or "Coremeter"). FIG. **2**A shows a block diagram of the gateway **110**. Similarly, FIG. **2**B shows a schematic layout for the gateway **110**. FIG. **2**C shows an exemplary housing **112** for the gateway. It will be appreciated that the embodiment of the media gateway **110** shown in FIGS. **2A-2C** is only one exemplary embodiment of a media gateway. As such, the exemplary embodiment of the media gateway **110** of FIGS. **2A-2C** is merely representative of any of various manners or configurations of the media gateway **110** or other data processing systems that are operative in the manner set forth herein.

The media gateway **110** is provided in a housing **112**, cabinet or the like, and includes a number of ports and associated electronic components enclosed within the housing **112**. As can be seen in FIG. **2**C, the housing **112** is a simple cube-shaped box structure with a solid color provided on the base (e.g., a gray color), and a contrasting color provided on an upper portion of the housing above the base (e.g., a black color). The display **152** of the gateway **110** is visible on the upper portion of the housing. The simple design of the housing **112** is intended to be both rugged and aesthetically pleasing. However, FIG. **2**C is only one of numerous possible embodiments for the housing **112**. FIG. **2**D shows an alternative embodiment of the housing that does not include the display **152**, but includes a number of additional antennas **128** associated with the wireless transceiver **124**.

With particular reference now to FIG. **2**A, the electronic components of the media gateway **110** include processing circuitry/logic **114**, a memory **116**, a communications module **120**, an infrared receiver **122**, a wireless transceiver **124**, a cellular transceiver **126**, a number of input/output ports **130**, a power module **150**, a display **152**, a microphone **154**, and a speaker **156**.

The processing circuitry/logic **114** is operative, configured and/or adapted to operate the content gateway **110** including the features, functionality, characteristics and/or the like as described herein. To this end, the processing circuitry/logic **114** is operably connected to the memory **116**, and various other components including the communications module **120**, the I/O ports **130**, the power module **150**, the display **152**, the microphone **154**, and the speaker **156**. The processing circuitry **114** may be provided by one or more commercially available microprocessors, such as a quad core 1.8 GHz or faster processor, such as those sold by Intel Corporation or AMD, Inc. The processing circuitry **114** may be included on a single board/processor, or may be split amongst a number of different boards and processors within the gateway **110**. For example, in at least some embodiments, the processing circuitry includes a CPU, a motherboard, and one or more additional processing modules, such as a video capture module **115** (see FIG. **2**B).

The memory **116** may be of any type of device capable of storing information accessible by the processor, such as solid state memory, hard drives, memory cards, ROM, RAM, write-capable memories, read-only memories, discs, flash memory, or any of various other computer-readable medium serving as data storage devices as will be recognized by those of ordinary skill in the art. In the embodiment, shown in FIG. **2**B, the memory includes 4 GB (or more) DDR3 RAM as well as 8 GB (or more) SSD storage.

The memory **116** is configured to store both instructions **160** for execution by the processing circuitry/logic **114**, as well as data **170** for use by at least the processing circuitry/logic when running one or more of the programs/software engines included in the instructions **160**. In the embodiment described herein, the instructions **160** include various software programs/engines, including OTT apps **161**, a content capture engine **162**, a client-side content identification engine **164**, a panelist registration engine **166**, a content overlay engine **168**, as well as numerous other computer programs. It will be recognized that the instructions **160** also include various additional programs that are not discussed in detail herein. For example, the instructions **160** include a hardware interface application programming interface (API) that allows the gateway **110** to interact with various hardware components such as the communications module **120** and associated transceivers **122**, **124**, **126**, I/O ports **130**, power module **150**, display **152**, etc.

The OTT apps **161** include any of various apps available to or downloaded by the user for use via the gateway **110**. The OTT apps may **161** include any of various applications for streaming OTT content, such as the Amazon Prime app, Hulu, Netflix, etc.

The content capture engine **162** is configured to select, copy and save certain screenshots, video snippets, and/or audio associated with the selected video source that is delivered to the television **200**. The content captured may be

from any of various media sources, including one of the sources connected to one of the I/O ports **130** (e.g., one of the HDMI-IN ports **132**) as well as any additional sources such as content provided by one of the OTT apps **161** included in the memory **116** of the gateway **110**. The content capture engine **162** captures/copies specific types of content (e.g., video frames) at certain times. The capture of content may occur periodically and/or be determined based on instructions from the content identification engine **164**. In at least some embodiments, the content capture engine **162** interacts with the hardware interface API and captures content every time an infrared signal is received from the remote control **206**. Content captured with the content capture engine **162** may be processed by the content identification engine **164** and/or transmitted to the remote server **310** for additional processing.

The client-side content identification engine **164** is configured to monitor, analyze and identify content presented on the television screen and other display devices using a multi-layered approach to content identification. As explained in further detail below, the multi-layered approach involves the application of different rules to content review and identification based on the source of the content. The content identification engine **164** advantageously uses machine learning to improve upon content identification over time. The content identification engine performs a first round of content recognition on the captured media by using machine learning models. If the client-side content identification engine **164** is able to detect the required information with enough accuracy, the detected information (e.g., channel and other metadata) are transmitted directly to the cloud and stored in a database of the remote server together with panelist registration information. On the other hand, if the content is not identified with an acceptable level of accuracy, the content is sent to the remote server **310** for further processing by more robust machine learning engines.

The panelist registration engine **166** operates in association with the content identification engine **164** to identify certain panelists for association with identified content. The panelist registration engine **166** works directly with the hardware interface API in order to detect the household member's presence using any of various means. For example, the panelist registration engine **166** may analyze the power of the Wi-Fi signal that arrives at the gateway **110** from wireless devices **220** (e.g., smartphones and other mobile devices) associated with each of the panelists. As another example, the panelist registration engine **166** may interact with a Bluetooth chipset **123** on the wireless transceiver **124** in order to detect the presence of Bluetooth wearables that are assigned to one or more of the panelists (typically child panelists). It will be recognized that the terms "register" and "registration" as used herein with respect to one or more panelists refers to the condition of a panelist being in proximity to the television or other display device such that the panelist is associated with identified content presented on the display device; the terms "register" and "registration" as used herein with respect to one or more panelists does not refer to such panelists being users of the system and/or simply having demographic information for the panelist saved in the system **100**.

The content overlay engine **168** is configured to display certain content on the television in association with media presented thereon. For example, as described in further detail below, the content overlay engine **168** is configured to overlay avatars representing the currently registered panelists over the video content presented on the television **200**. The content overlay engine **168** is also configured to provide various graphical user interfaces (GUIs) for use in association with gateway operation. In at least some embodiments, the content overlay engine **168** also includes the software that operates the video capture module **115** of the gateway **110**. In this embodiment, the content overlay engine **168** determines the video signal output at the HDMI-OUT port **133** of the gateway. Accordingly, the content overlay engine **168** may be configured to determine the programming/media content presented on the television in addition to any overlays on the programming/media content.

With continued reference to FIG. **2**A, the data **170** stored in the memory **116** includes panelist data **172**, a viewing log **174**, training data **176**, and saved content. The panelist data **172** includes data related to all panelists **204** in the household **202**. The panelist data **172** may include any of various types of demographic data such as age, sex, income level, etc. for each panelist within the household **202**. In at least some embodiments, the panelist data **172** also includes personalized information collected about the panelist at the time of registration. For example, the panelist data **172** may include education level, type of smartphone owned, type of automobile owned, pet ownership, vacation preferences, sports preferences, food preferences, etc.

The viewing log **174**, includes information about the content viewed by the individual panelists. For example, the viewing log **374** may include individual data indicating that a particular panelist was watching a particular program at a particular time. For example, the viewing log **174** may include data indicating two panelists **204** from the household **202** were watching "Game of Thrones" on HBO via a cable box at 10 pm on Jul. 9, 2020. The viewing log **174** may be saved to the memory **116** of the gateway **110** for some period of time, and then periodically transmitted to the remote server **310** (e.g., at the end of every day), and/or erased after some period of time (e.g., after one month).

The training data **176** includes data that is used by the machine learning features of the client-side content identification engine **164**. The training data includes a number of exemplary video frames for different input sources, and the appropriate content identification for such video frames. The training data **176** is used to train the content identification engine **164** to appropriately identify content from a video frame. The training data **176** is periodically updated (e.g., daily, weekly, etc.) by uploading additional training data from the remote server **310**. This updated training data allows the content identification engine **164** to experience incremental learning, thus allowing the content identification engine to more reliably identify content from any of various input sources.

The saved content **178** includes frames of captured video that are saved for future reference. While much of the content identification process occurs locally on the gateway **110**, in certain situation frames that require further processing are temporarily stored in the saved content **178**. These frames may then be transmitted to the remote server **310** for further processing. For example, when certain types of frames that require more in-depth processing (e.g., face identification) are identified, these frames are temporarily stored with the saved content **178**, and then subsequently transferred to the remote server **310** for further processing. In some instances, transfer of the saved content occurs along with content data that was identified at the gateway **110** (e.g., text data associated with each frame).

In view of the foregoing, it will be recognized that the data **170** is used by the computer programs **162**, **164**, **166**, **168** utilize the data **170** in order to provide the functionality of the cross-media content identification system **100** described

herein. A computer program product implementing an embodiment disclosed herein, including any of the above-mentioned programs may comprise one or more computer-readable storage media storing computer instructions executable by a processor to provide an embodiment of a system or perform an embodiment of a method disclosed herein. Computer instructions (e.g., the client-side content identification engine **164**) may be provided by lines of code in any of various languages as will be recognized by those of ordinary skill in the art. A "non-transitory computer-readable medium" may be any type of data or storage medium that may store computer instructions, including, but not limited to a memory card, ROM, RAM, write-capable memories, read-only memories, hard drives, discs, flash memory, or any of various other computer-readable medium.

With continued reference to FIG. **2**A, the communication module **120** of the gateway **110** provides an interface that allows for various types of communication with any of various media devices. The communications module **120** is specifically configured for both wired and wireless communications with various media devices and other electronic devices. The communications module **120** is configured for wireless communications via the I/O ports **130**, and is configured for wireless communications via various wireless interfaces, including an infrared receiver **122**, a wireless transceiver **124**, and a cellular transceiver **126**.

The communications module **120** connects the gateway **110** to the household's internet service provided by an internet service provider (e.g., via cable or fiber delivered to a household modem). The connection to the internet may be by wired communication (e.g., over the Ethernet port **142**) or wireless communication (e.g., over the wireless transceiver **124**). For example, the wireless transceiver **124** connected to the communications module **120** specifically includes a Wi-Fi chipset **125**, thus allowing the communications module **120** to communicate with an existing Wi-Fi network provided by an internet service provider. Connection of the communications module **120** to the internet allows the gateway **110** to serve as a router in a new wireless network within the household. Thus, the gateway **110** serves as a Wi-Fi access point for all wireless network devices **220** within the household, including both mobile devices (e.g., smartphones and tablets) and stationary devices (e.g., desktop computers and the television **200**). Besides acting as a router/Wi-Fi access point, the Wi-Fi chipset **125** also allows the gateway **110** to sniff the traffic on each mobile device and detect mobile browsing history, searched keywords and target URLs. Additionally, the Wi-Fi chipset **125** detects the signal strength (e.g., RSSI) of each mobile device at the gateway, thus allowing the gateway **110** to detect proximity of a mobile device (and the associated user) to the gateway. Thus, it will be recognized that the Wi-Fi chipset **125** provides for triple functionality: (i) it can connect to a Wi-Fi network as a client (e.g., in order to transmit captured date to a central server or receive software updates); (ii) it can act as a Wi-Fi access point such that other Wi-Fi devices connect to it (e.g., in order to perform network sniffing functions to determine the kind of contents the user is consuming); and (iii) it can act as a Wi-Fi beacon in order to detect the proximity of a mobile device (e.g., in order to allow for passive user presence detection in the same room as the television).

In addition to the wireless transceiver **124** and associated Wi-Fi chipset **125**, the communications module **120** further includes a cellular transceiver **126** (or other wide area network transceiver) and associated chipset. The cellular transceiver **126** may include a cellular modem that facilitates internet communications between the gateway **110** and any of various remote computers via the cellular telephony network (e.g., 3G/4G/5G/LTE networks within the American frequency specification). In this manner, the gateway **110** is equipped with redundant functionality that allows for internet communications via any one of various available network connections, including: (i) an Ethernet connection, (ii) a Wi-Fi connection, or (iii) the cellular telephony network connection.

In addition to the internet connection capabilities, including Wi-Fi and cellular capabilities as discussed above, the communications module **120** also includes further wireless communications capabilities. For example, the infrared receiver **122** allows the communications module **120** to receive infrared signals from a remote control or other infrared-equipped device. Additionally, the wireless transceiver **124** may also provide other communications capabilities using any of various known hardware, software and related communications protocols. For example, the wireless transceiver **124** is also configured to provide short-range wireless communications (e.g., via the low emissions Bluetooth chipset **123**) with any of various short-range communications devices. The short-range wireless communications provides additional functionality for the gateway **110**, such as additional remote control functionality, or panelist registration functionality as will be explained in further detail below.

The I/O ports **130** include a number of ports that are accessible through the housing **112** of the gateway **110**. As best shown in FIG. **2**B, the I/O ports **130** include a plurality of HDMI-IN ports **132** (e.g., 4-8 ports), an HDMI-OUT port **133**, a plurality of USB ports **134** (e.g., 2-4 ports), at least one CVBS-IN port **136**, a CVBS-OUT port **137**, and a digital antenna in port **138**. The HDMI-IN ports **132** are configured to connect any of a plurality of different wired media sources **210** to the gateway **110** using an HDMI cable having an HDMI connector. Typical media sources that may be connected to the gateway **110** via the HDMI-IN ports **132** include cable boxes, Blu-ray and DVD players, OTT streaming devices (e.g., Apple TV, Roku, Amazon Firestick, etc.), video game consoles (e.g., Sony PlayStation, Microsoft X-Box, Nintendo Switch, etc.), video cameras, and any number of other media devices.

Similar to the HDMI ports, the USB ports **134** are configured to connect any of a plurality of different wired media sources **210** to the gateway **110** using a USB cable with a USB connector. Typical media sources that may be connected to the gateway **110** via the USB ports **134** include video cameras and computer devices such as tablets, laptops, and desktop computers. The USB ports **134** are particularly equipped to allow system administrator to perform activities such as operating system updates, media files transfer, extend storage capacity, add external dongles of any kind to expand the hardware capacity, and connect peripheral accessories such as biometric readers, webcams or other sensors.

The at least one CVBS port **136** is available in the event that a wired media source **210** does not include an HDMI port (e.g., an older media device, such as a VCR), in the event that composite video cables are available but an additional HDMI cable is not available to the user during set-up of the gateway **110**, or in the event that all of the HDMI ports **132** are in use. The digital antenna in port **138** is generally a coax connection port that receives input from an HDTV antenna. The digital antenna in port is connected

to a digital ATSC TV tuner **139** that allows the user to receive OTA content from any of a number of local TV providers.

Each of the video input ports, including the HDMI-IN ports **132**, USB ports **134**, CVBS-IN port **136**, and TV tuner **139** are connected to the video capture module **115**. The video capture module **115** is configured to receive video signal inputs from the various ports **132**, **134**, **136**, **139**, and act as a switch to select one of the inputs to be output to the television via the HDMI-OUT port **133** (or alternatively, the CVBS-OUT port **137**). Selection of the appropriate video signal for output via the HDMI-OUT port **133** is typically determined by user/panelist selection of one of the input ports via the remote control or other means, thus indicating the user's preferred viewing source. The video signal from the selected input port is then output to the television for presentation to the user. Accordingly, a single HDMI input is received at the television **200** from the gateway **110**, and there is no need for the user to switch video inputs at the television. Instead, selection of video inputs occurs at the gateway **110**. Furthermore, because the video signal to the television is directed through the gateway **110**, the content overlay engine **168** is configured to overlay additional content, such as legends, alerts and registered persons, on the television screen via the HDMI-OUT port **133** to the television **200**.

In addition to the video input ports, the I/O ports also include several additional ports including an SD card expansion slot **140**, an Ethernet port **142**, and an AC output port **144**. The SD card expansion slot **140** allows the user to insert an SD card so that content thereon can be read by the gateway **110**. For example, the SD card expansion slot **140** may be used as an expansion slot for additional storage capabilities when connectivity problems exist with the gateway **110** (e.g. due to faulty Wi-Fi at the household or problems with the cellular network). Alternatively, the SD card expansion slot **140** may be used to provide updates or other information for use by the processing circuitry **114**. The Ethernet port **142** (e.g., an RJ45 10/100 MBPS Ethernet port) is configured to connect to the household modem provided by an internet service provider (ISP). The Ethernet port **142** is typically used when the internet modem provided by the ISP is in close proximity to the gateway **110**. If this modem is not in close proximity to the gateway **110** (or otherwise available for wired connection), the gateway utilizes the wireless transceiver **124** or the cellular antenna **126** to connect to the household router provided by the ISP. The AC output port **144** is connected to the power module **150**. As explained in further detail below, the AC output port **144** is configured to receive the power cord from the television **200** and provide AC power to the television.

The power module **150** is adapted to provide power to both the gateway **110** as well as the television. To this end, the power module **150** includes an internal power supply that is configured to plug in to an AC power outlet within the household **202**. The power module **150** is also connected to an internal battery **148**. The power module charges the internal battery **148**, and in turn, receives power from the internal battery **148** in the event power from the household AC power outlet is not delivered to the power module **150**. As shown in FIG. **2**B, the internal power supply is connected to the AC output port **144** and provides power to the AC output port. In order to facilitate delivery of AC power, the AC output port **144** includes an AC receptacle **145** that other electronic devices may be plugged into. When the television **200** is plugged into the receptacle **145** of the AC output port **144**, the television receives power via the gateway **110**.

The power module **150** also includes a TV ON/OFF detection circuit **151**. The TV ON/OFF detection circuit **151** is configured to determine whether the TV connected to the gateway **110** is on or off in one of two different ways. First, if the TV is plugged into the AC power port **144**, the circuit **151** detects the amount of power flowing to the television (e.g., via an AC loop sensor or other current sensor or via a shunt resistor or other voltage sensor). When the amount of power provided to the television **200** is less than a threshold amount (i.e., indicating that the screen is not illuminated), the television is determined to be powered off. When the amount of power provided to the television is greater than a threshold amount (i.e., indicating that the screen is illuminated), the television is determined to be powered on. Second, if an HDMI cable connects the gateway **110** to the television, the HDMI CEC (consumer electronics control) feature may be used to detect whether the television **200** is powered on or off. As explained in further detail below, determining whether the television **200** is powered on or off may be used to (i) establish the measurement on/off times based on the times the user is actually watching television, (ii) optimize resource usage by processing and transmitting information only when the user is watching television, and (iii) detect user presence only during television viewing times. Also, because the gateway can detect the ON/OFF television state, the power module **150** is further configured to automatically turn on (full power) when the television **200** is turned on, and automatically turn off (reduced power) when the television is turned off.

With continued reference to FIGS. **2**A-**2**C, the gateway **110** further includes additional electronic components such as a display **152**, a microphone **154**, and a speaker **156**. The display **152** may be a conventional LCD display (e.g., a 16×10 cm LCD display), as shown in FIG. **2**C. The display **152** provides simple information for the user such as the current time, date, selected media source (e.g., HDMI **2**), and registered panelists (e.g., 1, 3, 4). The display **152** may also be used by a technician to provide information during diagnostic testing and repair of the gateway **110**. However, the display **152** is not equipped to present video content from any of the sources connected to the ports **130**. In other words, the gateway itself is not capable of acting as a television for user viewing of video signals delivered thereto.

The microphone **154** may be any of various commercially available microphones that are commonly used with electronic devices. The microphone **154** allows the user to provide verbal instructions in lieu of instructions from a remote control or other source (e.g., "Alexa, tune to Netflix," or "Hey Google, what channel is playing the football game"). The speaker **156** is capable of providing audible cues, alerts, reminders, or audio instructions for the user. For example, the speaker **156** may sound an error tone, or may be used to respond to a verbal command from the user (e.g., "The football game is on NBC, channel 12"). In at least one embodiment, the microphone **154** is used to provide additional content identification capabilities, such as audio ACR.

Remote Server

With reference again to FIG. **1**, the remote server **310** is positioned at a location that is removed from the household **202** where the gateway **110** resides. The remote server **310** is configured to communicate with the gateway **110** via the internet **290**. Accordingly, both data and instructions may be communicated and shared between the gateway **110** and the remote server **310** via the internet **290**. While only a single remote server **310** is shown in FIG. **1**, it will be recognized that this single server **310** is representative of any number of

remote/cloud servers that may be in communication with the gateway via the internet **290** or other wide area network.

As shown in FIG. **3**, the remote server **310** is provided in a housing **312**, cabinet or the like, and includes a number of electronic components enclosed therein. In particular, the remote server **310** includes processing circuitry/logic **314**, a memory **316**, a communications module **320**, and a number of input/output ports **330**. The communication module **320** of the remote server **310** provides an interface for communication with other devices, and particularly the gateway **110**, via the internet. As noted previously, the gateway **110** is connected to the internet using any of various means for establishing internet communications. The remote server **310** may be similarly configured, including configured for wired or wireless connection to the internet. To this end, the I/O ports **330** of the remote server provide the necessary ports, antennas, or other communications hardware required to establish the internet connection.

The processing circuitry/logic **314** of the remote server **310** is operably connected to the memory **316**, and various other components including the communications module **320** and the I/O ports **330**. Similar to the processing circuitry **114** of the gateway **110**, the processing circuitry **314** of the server **310** may be provided by one or more commercially available microprocessors, such as a quad core 1.8 GHz or faster processor, such as those sold by Intel Corporation or AMD, Inc. The memory **316** may also be of any type of device capable of storing information accessible by the processor, such as solid state memory, hard drives, memory cards, ROM, RAM, write-capable memories, read-only memories, discs, flash memory, or any of various other computer-readable medium serving as data storage devices as will be recognized by those of ordinary skill in the art. The memory **316** is configured to store both instructions **360** for execution by the processing circuitry/logic **314**, as well as data **370** for use by at least the processing circuitry/logic when running one or more of the programs/software engines included in the instructions **360**.

In the embodiment described herein, the instructions **360** include various software programs/engines, including a network-side content identification engine **364**. The network-side content identification engine **364** is similar to the client-side identification engine **160**, and is configured to identify content presented on a television. However, the network-side content identification engine **364** includes additional functionality and processing capabilities, such as increased machine learning functionality beyond that capable with the client-side content identification engine **160**.

The data stored in the memory **316** includes panel-wide data **372**, a viewing log **374**, and training data **376**. The panel-wide data **372** includes data related to all panelists in the system **100**, including the panelists **204** associated with the household **202**, as well as numerous additional panelists associated with additional households. The panel-wide data **372** may include any of various types of demographic data such as age, sex, income level, etc. for each panelist. The viewing log **374**, includes information about the content viewed by panelists, both individually and collectively. For example, the viewing log **374** may include individual data indicating that a particular panelist was watching a particular program at a particular time (e.g., panelist **1** from the household **202** was watching "Game of Thrones" on HBO at 10 pm on Jul. 9, 2020). Additionally, the viewing log **374** may include collective data that indicates that groups of panelists were watching a particular program at a particular time (e.g., 5% of all panelists, or 10% of all males between the ages of forty and fifty were watching "Game of Thrones" on HBO at 10 pm on Jul. 9, 2020). The training data **376** includes data that is used by the machine learning features of the network-side content identification engine **360**, as explained in further detail herein.

General Gateway Operation

General operation of the gateway **110** is now be described with reference to FIGS. **4-7**. FIG. **4** shows the gateway **110** positioned in a living area of an exemplary household **202**. The gateway **110** is positioned in close proximity (e.g., within 5-10 feet) of the television **200**. The HDMI-OUT port **133** of the gateway **110** is connected to one of the HDMI-IN ports **201** of the television **200**. A plurality of wired media sources **210**, including a cable box **212**, Blu-ray/DVD player **214**, and a gaming console **216** are connected to the gateway **110** using cables connected to the HDMI-IN ports **132** of the gateway **110**. Wireless devices **220**, including a smartphone **222** and a wearable device **230** (e.g., a smart bracelet), are also connected to the gateway **110** via the wireless transceiver of the gateway **110**. A remote control **206** is also configured to communicate with the gateway **110**.

The gateway **110** is configured to identify content presented on the television **200** and associate one or more panelists **204** with the identified content. Additionally, the gateway **110** is configured to communicate with the smartphone **222** over a Wi-Fi connection in order to monitor media content presented on the smartphone **222**. The gateway **110** is also configured to register panelists **204** and associate registered panelists with identified media content on the television **200**. Registration of panelists is accomplished in one of several ways. First, passive registration of panelists may occur using the wireless connection with the smartphone **222** (or other mobile electronic device) to detect user presence in proximity to the gateway **110**. Second, passive registration of panelists may occur using the wireless connection, e.g., a Bluetooth connection, with the wearable device **230** in order to detect user presence in proximity to the gateway. Third, active registration of panelists may occur using the remote control **206**. To this end, the remote control **206** includes a plurality of dedicated registration buttons for active registration of the panelists to the gateway. Each of the dedicated registration buttons is associated with one of the panelists in the household **202**, such that the panelist only needs to press a button in order to actively register their presence in proximity to the television **200**. Further detail concerning registration of panelists is provided in further detail below in association with the "Active and Passive Panelist Registration" subheading (and related FIGS. **11-17**).

With reference now to FIGS. **5A-5B4**, a method **500** of cross-media content measurement is disclosed. The method **500** begins at block **502** when the gateway **110** is turned on (the terms "block" and "step" are used interchangeably herein). At block **504**, a check is made that the gateway **110** is receiving power from an AC wall outlet. If the gateway is not receiving power from an AC wall outlet, the device is instructed at block **506** to operate from the battery until power is received from the AC wall outlet. At block **508**, the process continues and the gateway goes through the booting process. Once the booting process is complete, the processor is instructed to overlay information about the gateway **110** on the television screen via the HDMI output. At block **512**, the gateway detects whether this is the first-time use of the device within a household. If it is a first time use, at block **514** the setup wizard is run, demographic data for each panelist in the household is entered, registration buttons from the remote control are associated to each of the

panelists, the MAC address of various wireless devices (e.g., smartphones and watches) are associated to the panelists, and wearable devices are associated with panelists (e.g., wearable bracelets for children). Then, at block **516** the gateway checks for an internet connection. If no internet connection is detected, the method continues to block **518** and an alert to request connectivity is issued, and the internet connection wizard is run.

Once an internet connection is established at the gateway **110**, the method continues to block **520**, and the gateway detects whether power to the television is on (e.g., via a current sensor or a CEC signal from the HDMI connection to the television). If power to the television is not on, no panelist presence or content identification is performed, and at block **522**, the gateway **110** periodically sends a diagnostic signal (e.g., every hour) to be sure that the television remains operational. If the television is powered on, the method continues to block **526**, and user registration (i.e., user presence in the vicinity of the television) is detected. As noted previously, the gateway **110** is capable of detecting user registration by any one of several means, including active user registration by a pressed button on the remote control **206**, passive registration based on signal strength from a user mobile device (e.g., smartphone **222**), or passive registration based on a wireless connection to a user wearable device (e.g., bracelet). If no panelists are detected, the method continues to block **528** and an alert is shown on the television instructing any panelists in the room to register (e.g., via the remote control). After one or more panelists are registered by the gateway **110**, the method moves on and performs the acts associated with the additional blocks shown in FIG. **5**B.

With reference now to FIG. **5**B, after one or more panelists are registered with the gateway **110**, the method continues at block **530** by determining which input source is selected for presentation on the television (e.g., HDMI **1-3** or OTA), and then obtaining content identification rules for the selected source. Again, the selected input source is the source that video capture module **115** has selected for delivery of the associated video signal to the television. This source may be selected by the user via the remote control, or may simply be the last selected source from a previous television viewing session. As will be explained in further detail below, the selected content identification rules may depend on the specific media input (e.g., cable box, OTA, OTT) as well as the specific device or content provider associated with such box (e.g., Spectrum cable box, Amazon Firestick, Roku, etc.). Depending on the selected input source, the method then implements the associated rules. As shown in FIG. **5**B, the method continues at block **532** (and FIG. **5**B**1**) when the selected input source is OTA television. The method continues at block **534** (and FIG. **5**B**2**) when the selected input source is a satellite/cable box. The method continues at block **536** (and FIG. **5**B**3**) when the selected input source is an OTT source (either connected to an input of the gateway **110** or on an app within the gateway). The method continues at block **538** (and FIG. **5**B**4**) when the selected input source is a disc player or game console. While four exemplary methods associated with content identification rules are illustrated in FIGS. **5**B**1**-**5**B**4**, it will be recognized that these are merely exemplary methods and numerous additional methods are contemplated for any of various input sources. Accordingly, the particular steps associated with each method, and any associated details (e.g., threshold amounts, times for processing, etc.) are merely illustrative and will change with different sets of content identification rules.

With reference now to FIG. **5**B**1**, an exemplary method **540** associated with content identification rules for an OTA television signal is shown. The method **540** includes two different analysis routines **541** and **551** that are processed in parallel. The first routine **541** is a signal analysis routine. This routine **541** begins at step **542** where the tuned signal (from the digital ATSC TV tuner **139**) is analyzed. Video signals transferred under the ATSC standard include metadata that identifies the tuned channel. Accordingly, analysis of the tuned signal with OTA content includes extracting the metadata from the signal in order to identify the content presented on the television screen. At block **543**, a determination is made if a threshold period of time (e.g., 5 seconds) has elapsed since the last analysis of the tuned channel. If the period of time has elapsed the method **540** returns to block **542** and the tuned signal is analyzed again. If the threshold period of time has not elapsed, the method **540** proceeds to step **544** where a determination is made whether it is time to transmit the identified content data. If it is not yet time to transmit the data (e.g., once every two seconds) to the remote server **310**, the method moves to block **546**. However, if it is time to transmit the data, the routine **541** continues, and the identified content data is transmitted at block **545**. Then, at block **546**, a determination is made whether a change in the selected media source occurred. If a change did not occur, the method returns to block **543** and again analyzes the tuned signal. If a change in the selected media source did occur, the method moves to step **547**, where the method returns to step **530** of FIG. **5**B and the selected input source for presentation on the television is detected.

With continued reference to FIG. **5**B**1**, in parallel with processing the metadata analysis routine **541**, the method **540** associated with the OTA content identification rules also includes a video frame analysis routine **551**. The video frame analysis routine **551** begins at block **548** where the processor waits for the next video frame from the OTA video signal. At block **552** a determination is made whether the next frame has been received. If the next frame has not been received, the method moves to step **546** and determines whether there was a change in the selected media source. On the other hand, if the next video frame has been received, the method continues to step **553**, and the video frame is captured. Then, at block **554**, a machine-learned frame analysis (e.g., logo analysis, face recognition, etc.) is performed on the video frame. At block **555**, a determination is made whether the frame indicates a scene change (as explained in further detail below). If there is not scene change at block **555**, the method continues to step **556**, and a determination is made whether the frame has useful information (i.e., identified additional content data). If additional content data is identified, it is then transferred at block **557**. If no useful content data is identified, the method returns to block **548**, and waits for a new video frame. On the other hand, if a scene change is detected at block **555**, the method continues to block **558** where a scene change timestamp is recorded and/or transmitted. This scene change timestamp is utilized to determine the length of an advertisement. At block **559**, the method continues by waiting for a new non-blank screen. The new non-blank screen indicates the beginning of a new content piece (e.g., the start of a commercial, or return to regular programming). When a new non-blank screen is received, the method then returns to block **553** and captures the video frame.

With reference now to FIG. **5**B**2**, an exemplary method **560** associated with content identification rules for a video signal from a satellite/cable box is shown. The method

begins at step **561** where the processor waits for the next frame in the video signal. At step **562**, a determination is made whether the next frame is received. It will be recognized that the next frame may be an immediately next frame, or could also be a next frame of some predefined number of frames (e.g., one in ten). If the next frame has not been received, the method continues to block **572**, and a determination is made whether there was a change in the selected media source. On the other hand, if the next frame has been received, the method continues to block **563**, and the next frame is analyzed to detect whether a content grid (e.g., banner, guide, mosaic, etc.) or network logo is present within the frame. As explained in further detail below, the algorithms for determining the presence of a content grid or network logo may be considered to be "trigger events." At block **564** the method determines whether the analyzed video frame includes a trigger event in the form of a content grid or network logo. If a content grid or network logo is present, the method continues at step **565**, and a machine-learned content grid analysis is performed and/or machine-learned network logo analysis is performed. The content identification data generated by such analysis is then packaged in a data package and transmitted to the remote server **310**. The method then returns to block **561** where the method waits for the next video frame.

With continued reference to FIG. **5**B**2**, if no content grid or network logo is detected at step **564**, the method continues to step **567**, and a determination is made whether the analyzed video frame includes another trigger event in the form of a scene change. If a scene change is detected, the method continues to step **568**, and a timestamp of the scene change is generated and stored internally and/or transmitted to the remote server. Thereafter, at step **569**, the method waits for a new non-blank video frame. When a new non-blank video frame is received, this indicates the beginning of a new content piece (e.g., the start of a commercial, or return to regular programming). The method then returns to block **563** and reviews the new frame.

If no content grid or network logo is detected at step **564**, and if no scene change is detected at step **567**, the method **560** continues to step **570**. At step **570**, the method determines whether yet another trigger event has occurred in the form of a predetermined passage of time (e.g., ten seconds) since the last video frame analysis. If the predetermined period has passed and it is time to review another video frame, the method **560** continues to step **571** and a machine-learned algorithm (which may also be referred to herein as a machine-learning module) performs an analysis on the frame. This machine-learned algorithm may be any of a number of machine-learned algorithms configured to detect content from a video frame, such as logo analysis, object detection, face recognition, etc. Following this analysis, the method continues on to step **566**, and any identified content is collected into a data package and transmitted to the remote server **310**.

If a determination is made at step **570** that it is not time to analyze another frame, the process **560** continues to block **572**, where the gateway **110** determines whether there has been a change in the selected media source. If there has been no change in the selected media source, the method **560** returns to step **561** and waits for the next video frame. On the other hand, if there has been a change in the selected media source, the method **560** proceeds to step **573**, where it is instructed to return to step **530** of FIG. **5**B.

With reference now to FIG. **5**B**3**, an exemplary method associated with content identification rules for a video signal from an OTT provider is shown. The method begins at step **581** where the processor waits for the next frame in the video signal. At step **582**, a determination is made whether the next frame was received. If the next frame has not been received, the method continues to block **590**, and a determination is made whether there was a change in the selected media source. On the other hand, if the next frame has been received, the method continues to block **583**, and a machine-learned algorithm analyzes the frame to determine if one of a number of different objects or indicia can be found within the frame. At step **584**, the processor determines whether the frame includes a content mosaic. If the frame does include a mosaic, the process **580** continues to block **585** and a machine-learned mosaic analysis and content browsing path are determined (as described in further detail below under the "Content Grid Detection" subheading). Then, at step **586**, the data generated by the mosaic analysis and content browsing algorithm is transmitted to the remote server.

If no mosaic is identified at step **584**, the process **580** of FIG. **5**B**3** continues at step **587**, and a determination is made whether any additional content information was identified in step **583**. If some useful content information (e.g., logos, objects, faces, etc.), the method continues to step **588**, and that data is transmitted to the remote server. If no useful content information was identified at step **587**, the method continues to step **589**, and a determination is made whether a predetermined period of time has passed since the last video frame capture and/or analysis. If the predetermined period of time has passed, the method returns to block **583**, and the machine-learned frame analysis is performed on the next frame. On the other hand, if the predetermined period of time has not passed, the method continues to step **590**, and a determination is made whether there has been change in the selected media source. If there has been no change in the selected media source, the method **580** returns to step **581** and waits for the next video frame. On the other hand, if there has been a change in the selected media source, the method **580** proceeds to step **591**, and the method then returns to step **530** of FIG. **5**B.

With reference now to FIG. **5**B**4**, an exemplary method associated with content identification rules for a video signal from a disc player or video game console is shown.

FIGS. **5**A-**5**B**4** illustrate a simplified exemplary operation of the system **100**. It will be appreciated that numerous additional steps have been excluded for the sake of simplicity. For example, in addition to continually monitoring the media input source, the system also continually monitors whether user registration has changed. Again, this is accomplished by monitoring input from the active registration buttons on the remote control **206**, as well as the passive registration techniques associated with the mobile devices associated with each panelist (e.g., smartphones, watches, bracelets, etc.). As explained in further detail below, when user registration information has changed, the information is overlaid on the content currently presented on the screen of the television **200**.

Although not shown as a particular step in the methodology of FIGS. **5**A and **5**B, it will be recognized that router capabilities of the gateway **110** allow it to also serve as a Wi-Fi sniffer that detects content consumed on other Wi-Fi-equipped devices (e.g., smartphones, tablets, desktop computers, etc.). In particular, simultaneously with monitoring the content presented on the television **200**, the gateway **110** is also configured to monitor Wi-Fi traffic at any of various devices connected to the gateway's Wi-Fi network. The content sniffed by the gateway **110** is tied to the panelist associated with the Wi-Fi-equipped device that presented the content. In this manner, all media content consumed at a

household **202** is collected by the gateway **110** and associated with individual panelists within the household. Methods associated with detecting content presented at Wi-Fi enabled devices is described in further detail below with reference to FIGS. **18-20** under the heading "Internet Activity Measurement."

By implementing the method of FIGS. **5**A and **5**B, the system **100** is equipped to improve upon conventional media content measurement devices. The system **100** implements unique hardware and software components and functionality in order to collect the appropriate data that is capable of providing an understanding of essentially all of the media content being consumed within a household and the specific panelists consuming such content.

FIG. **6** is an illustration showing a data series **600** collected from an exemplary household/family of panelists within a single day. The household includes the following panelists; (i) a 43 year old adult female, (ii) a 45 year old adult male, (iii) an 11 year old boy, and (iv) a 4 year old girl. As shown in the illustration, at some time between 9:00 am and 11:00 am, all of the panelists are present in the kitchen and the gateway identifies the program "CBS Sunday Morning" as presented on the kitchen television. The program airs for some period of time (e.g., from 9:15 to 11:00 am) and all panelists are identified with the show during this period of time. During this time a number of ads are also identified as been presented to the panelists. These ads include the Suave "Art Exhibit" ad, the Casper "Only Casper" ad, the Naked "Steps" ad, the Chipotle "Kitchen" ad, as well as a number of additional ads as shown in FIG. **6**. Also during this time, the gateway **110** identifies that content from the "Food Network" app was presented to the adult female on her device. The gateway also identifies that content from the "ESPN" app was presented to the adult male. The television is turned off around 11:00 am, at which time the 11 year old boy goes to the basement where he watches a "Spongebob Squarepants" episode in the basement using Roku via the Amazon Prime app. At some point after 11:30 am, the adult female and the 4 year old girl go to the bedroom and watch the PBS show "Daniel Tiger" via video on demand. The collection of data concerning consumed media content then continues throughout the day, until all devices are turned off by 10:45 pm. Advantageously, the data collected includes data describing the display device, where the device is located (i.e., if a non-mobile device such as a television), the platform and/or apps used to watch the media content (e.g., cable TV, Amazon Prime, etc.), the specific content watched (e.g., ads, programming, gaming, etc.), the specific the panelists watching the content, and the time the content was watched. The collected data for the household is periodically transmitted to the remote server **310** throughout the day.

FIG. **7** shows an exemplary set of data **700** collected from a number of different households on a particular day (e.g., Jan. 15, 2020). This data set **700** includes a number of fields **702** identifying the media consumed, a number of fields **704** identifying the panelist who consumed the data. Advantageously, the data may be processed in order to identify trends in the data. For example, the data may indicated that 25% of adults between the ages of 25 and 35 who subscribe to cable watched a particular network drama (e.g., "Game of Thrones") on this day, and 80% of those viewers were exposed to a particular advertisement. The data set **700** may also be further processed to expose additional information and trends. For example, the data set **700** may indicate that 5% of the viewers exposed to a particular advertisement actually searched for the advertised content on their smartphone within ten minutes of viewing the advertisement. Therefore, by collecting and analyzing data using the gateway **110**, advertisers, programmers, and others in the media industry are equipped to learn the level of exposure of programming and advertisements, and responses to such programming and advertisements. This also equips those in the media industry to make informed decisions with respect to future programming and advertisements.

Multi-Layered Approach to Content Recognition

As noted above the gateway **110** is configured to identify media content presented on a television **200**. The gateway does this by first identifying what source is providing the television input, and then applying different rules to determine the content based on the identified source. Because of the different rules associated with different input sources, the gateway **110** is considered to take a "multi-layered approach" to content identification.

To further illustrate the multi-layered approach, consider the exemplary arrangement of FIG. **8** wherein five input sources are connected to the I/O ports of the gateway **110**. The input sources include four HDMI inputs, including a cable/satellite box **212** connected to the HDMI-IN 1 port, a Blu-Ray/DVD player **214** connected to the HDMI-IN 2 port, a video game console connected to the HDMI-IN 3 port, and an OTT device connected to the HDMI-IN 4 port. These four HDMI inputs are fed to the video capture module **115** of the gateway **110**. The fifth input source is a digital TV antenna input **219**, which is fed to the video capture module **115**. The video capture module **115** includes various hardware and software components for processing the received signals, including an ATSC tuner **139** (which receives the antenna input **219**), an HDMI capture API **163** (which may be considered part of the content capture engine **162**), and various OTT apps **161**. Using the remote control **206**, the user selects one of the four input sources for presentation (i.e., display) on the television **200**. The video capture module **115** then outputs the video signal associated with the selected input source to the television **200** via the HDMI-OUT port of the gateway **110**.

The video signals delivered to the video capture module **115** via the four HDMI inputs are all industry standard video signals. The video signals delivered to the video capture module **115** via the antenna and the ATSC tuner **139** are ATSC or other standard broadcast signals. The video signals delivered to the video capture module **115** may be characterized as a series of still images called "frames" (or screen shots) that are delivered in rapid succession at a constant interval (i.e., frame rate). As the frames of video are received by the video capture module **115**, the frames from the selected input source are passed on through the HDMI-OUT port **133** and to the television **200** where they are then presented on the television screen. During this time, the video capture module **115** analyzes selected frames of the video signal presented on the television. The frames selected for analysis are determined by a specific set of content identification rules that are dependent on the selected input source. The content identification rules define the method for processing the associated video signal, including rules for identifying video frames for content identification analysis, and what procedures for content identification will be applied to the identified video frames. In some rule sets, each and every frame from a particular source may be monitored and, based on certain trigger events, selected frames may then be subjected to additional in-depth analysis. In other rule sets, only predetermined frames are selected for in-depth analysis following the occurrence of a trigger events. As used herein, the term "trigger event" refers to some occurrence indicating that a subsequent more in-depth con-

tent analysis should be conducted on one or more video frames in an attempt to determine the media content presented on a screen device (e.g., the television **200**). In at least some embodiments, the frames associated with a trigger event are not only analyzed, but also captured (i.e., stored in memory), and/or transmitted to the remote server **310** or cloud for additional processing.

A number of different trigger events are possible. In general, trigger events may be split into two categories: (i) video frame triggers (which may be referred to herein as "frame triggers"), and (ii) external triggers unrelated to the video frame (which may be referred to herein as "external triggers" or "non-frame triggers"). Frame triggers occur when a preliminary analysis is conducted on a video frame which indicates that some trigger event is happening. Frame triggers are often used in rule sets where the video frames associated with a video signal are regularly monitored (e.g., many, most or all of the frames are subjected to some preliminary frame analysis). A first type of frame trigger occurs when a programming grid or content banner is included in one frame of the stream of frames. For example, this trigger event may occur when the preliminary analysis of a video frame includes pixels indicative of content banner or programming grid (e.g., a box or grid structure overlaid on some portion of the screen that includes some programming information, including information for a single channel and/or information for multiple channels). A second type of frame trigger occurs when a scene change is detected in the video signal. For example, the preliminary analysis of the stream of video frames may include comparing consecutive frames in the video input in order to detect a temporary blank screen (e.g., five consecutive blank screens), or a threshold change in the pixel density from one frame to the next (e.g., as may be the case when the content changes from network programming to an advertisement). A third type of frame trigger occurs when a network logo appears or does not appear within a frame. Inclusion of a network logo is generally indicative of network program content. Similarly, a missing network logo may be indicative of advertising or other content that is not created by the network. While three frame triggers are mentioned herein, it will be recognized that numerous additional frame triggers are possible and contemplated for use in the field. As discussed in further detail herein, frame triggers are often provided by the analysis from one or more local machine learning engines configured to detect such frame triggers.

Unlike frame triggers, external triggers are not related to the video frame itself. A first type of external trigger occurs when an infrared signal (or other type of signal, such as a short-range RF signal) is sent to the gateway **110** from the remote control **206**. The signal may be any number of different possible signals sent from the remote control **206**, such as a channel change signal, volume change signal, input source change signal, menu signal, television guide signal, etc. A second type of external trigger occurs when a signal for the gateway **110** is received from a source other than the remote control, such as a user voice signal. Again, this signal may be any number of different signals associated with control of the television via the gateway. A third type of external trigger occurs is when the gateway **110** detects a change in panelist registration occurs (i.e., an individual considered to be consuming the displayed content) is detected. A fourth type of trigger event is the expiration of a threshold period of time since the last trigger event (e.g., 500 ms, one second, one minute, five minutes, etc.). This trigger event ensures that the input video signal is captured and analyzed at least periodically (e.g., every five minutes), even if no intervening trigger events occur. While four types of external triggers are mentioned herein, it will be recognized that numerous additional external triggers are also possible. Additional information and descriptions of various triggers, including examples of external triggers and frame triggers, are provided below under the "Exemplary Trigger Events" subheading.

As noted previously, each set of content identification rules defines different signal monitoring procedures and trigger events. When a trigger event occurs, the video capture module **115** strategically analyzes one or more frames of the selected video signal as defined by the rule sets. The gateway **110** may define any number of different rule sets for content identification. For example, in the embodiment of FIG. **8**, a first set of rules with a process flow similar to that of FIG. **5**B**1** is used if the selected video signal for display on the television is received from the antenna input/ATSC tuner **139**. A second set of rules with a process flow similar to that of FIG. **5**B**2** is used if the selected video input signal is received from the satellite/cable box **212**. A third set of rules with a process flow similar to that of FIG. **5**B**3** is used if the selected video signal is received from the OTT device **218**. A fourth set of rules similar to that of FIG. **5**B**4** is used if the selected video signal is received from the Blu-ray player **214** or the gaming console **216**. Following application of each rule set, a data package is generated that includes content identification data for the associated media content presented on the television. Because each rule set is different, it will be appreciated that each data package is also different.

One example of a content identification rule set procedure is now provided in the context of the selected video source being the satellite/cable box input **212** of FIG. **8**, and the rule set being a first set of rules. This first set of rules is uniquely adapted to analyze frames of the video signal from the satellite/cable box **212** and assemble a data package for the analyzed frames. As noted previously, the rule set defines the method for processing the associated video signal, including rules for identifying video frames for content identification analysis, and the specific in-depth content identification algorithms that will be applied to the identified video frames. In this example, consider that the exemplary rule set defines a process flow that is somewhat similar to that of FIG. **5**B**2**, but instead of analyzing each and every frame of the video signal for frame triggers, the rule set defines frame analysis windows that follow immediately after the occurrence of external triggers.

Each frame analysis window defines a short time period following a specific trigger event when one or more frames are captured and/or analyzed (e.g., one frame, two frames, ten frames, all frames, etc.). As an example, when the external trigger event is receipt of a remote control signal to change the channel, the rules define a frame analysis window that occurs between one and five seconds after the trigger event, and a frame is captured every 0.5 seconds during this time. The defined frame analysis window is based on the expected or possible occurrence of some content information being displayed on the television screen within the defined window. This content information may be displayed in any number of different ways, depending on the specific cable provider, such as different types of content grid (e.g., a banner overlaid along the bottom of the image, or a programming guide overlaid on some portion or most of the television screen), a simple display of text, or even audio played for the viewer (in the case of audio, the gateway is configured to store the audio as text). The first set of rules strategically defines this frame analysis window based on

the particular input source (e.g., set-top box) connected to the gateway **110**, which may include a specific model of set-top box. The term "model" of set-top box may refer to a specific content provider (e.g., AT&T Uverse, DirectTV, etc.) and/or a specific model number and/or part number of the set-top box. For example, an AT&T Uverse box having model number 123456 may place a content box with a blue-colored background along the bottom of the screen between one and four seconds after the receipt of a channel change signal. In this case, the content identification rules for this set-top box defines an associated frame analysis window (e.g., one to four seconds following detection of the banner) that utilizes a machine-learned algorithm to detect the presence of the AT&T content banner in one of the video frames within frame analysis window.

In addition to defining a frame capture window, the first set of rules incorporates machine learning modules within the content identification engine **164**, and is configured to analyze an identified video frame (or multiple frames) and provide outputs that identify the content being watched on the screen. The outputs primarily include data identifying what is being watched on the television (e.g., program name, channel, time, etc.), but may also include additional information, such as identified logos, faces, characters, etc. Thus, the content identification engine **164** includes a number of different machine-learned algorithms, each of which implement a number of different tools/hidden layers. Examples of these tools include a text recognition tool (e.g., OCR), and other computer vision tools such as a logo recognition tool, a character recognition tool and/or a face recognition tool. Selected ones of these machine-learned algorithms may be executed in parallel to arrive at the defined content for a particular video frame.

The machine learning engine may also implement additional tools to arrive at the content identification data. For example the machine learning engine includes a text classification tool that identifies a category/field for all of the text extracted from a content grid from a particular provider (e.g., an identification that specific text is associated with a program name, program time, program description, channel, current time, etc.). The text classification tools are dependent at least in part on the particular provider (e.g., AT&T) and the expected position of certain information on a banner or other grid from such provider (e.g., the network is on the left side of the banner, the program name is in the middle of the banner, and the channel number is on the right side of the banner).

With reference now to FIG. **9**, a screen shot **250** associated with an exemplary video frame captured by the gateway **110** is shown. FIG. **9** also shows content identification data **260** extracted from the video frame using the first set of rules described above (i.e., a rule set associated with the cable box **212**). As shown in the screen shot **250**, a programming banner **252** is overlaid on the program content **254** on a lower portion of the screen. The banner **252** includes a significant amount of text **256** that may be used to identify the program content. The machine learning engine reads the text **256**, splits the text into different blocks of text, and then categorizes each block of text (e.g., program name, program time, program description, channel, current time, other information). Again, the categories for each block of text may be derived based on the known source (e.g., AT&T Uverse cable box), and the known location of data within the AT&T Uverse content grid/banner.

In the example of FIG. **9**, the rule set has extracted 184 characters of text from the frame, split the extracted text into blocks, and identified data categories and associated data for each category, as shown in the following table:

TABLE 1

Data Category	Extracted Data
Program name	"Malcom in the Middle"
Program time	"3-3:30pm"
Description	"Lois' Sister," S5/Ep13, (2004), (TV-PG,L), Lois and her competitive sister must reconcile because Susan . . . "
Channel	885 FUSE
Current time	3:24 pm
Other information	3HDDOD, CatPG

While table 1 illustrates an example of extracted text from a frame of video, and categorization of such data in order to identify programming content, it will be recognized that additional data may also be extracted from a frame of video. Examples of such additional information include logos, faces, products (e.g., cars, shoes, etc.), image labels (e.g., houses, cars, trees, animals, etc.), or any other information that may be of assistance in content identification and that the machine learning engine is trained to recognize.

The content identification data is incorporated into a data package for each analyzed video frame. Each data package includes different information, depending on the input source of the content. For example, different types of additional information associated with different input sources may include a viewing source, viewing type, viewing platform/provider, application name, and program type, and system information from the time of capture. The input source may include, for example, paid TV, OTA TV, recorded content, streaming content, video game, mobile source, etc. The viewing type may include, for example Live TV, Playback, video on demand (VOD). The viewing platform/provider may include, for example, AT&T set top box, Comcast set top box, Xbox console, PlayStation console, AppleTV, Amazon Firestick, etc. The application name may include, for example, Netflix, Amazon Prime, Hulu, etc. The program type may include, for example, TV program, TV ad, movie, video game, etc. System information from the time of capture includes, for example, a timestamp, TV on/off status, etc. Additional information on various data packages is provide below under the "Data Packages" subheading.

Exemplary Trigger Events and Content Identification Algorithms

A more detailed explanation of various trigger events and associated content identification programs are now described with reference now to the exemplary triggers illustrated in FIGS. **10**A-**10**L. As discussed previously, numerous sets of content identification rules are stored in the gateway, and each set of content identification rules includes one or more defined triggers. The gateway **110** applies one set of content identification rules to the video signal output to the television. The applied set of content identification rules is based on the selected input (i.e., the input to the television **200**, which is the output of the gateway **110**).

Infrared External Trigger Event

FIG. **10**A illustrates a first exemplary external trigger event in the form of an infrared signal from a remote control. The trigger event is included with a particular set of content identification rules associated with a particular cable box (e.g., a Comcast cable box). In the example of FIG. **10**A, the infrared signal is received from the gateway's remote con-

trol **206**, but it will be appreciated that the trigger event could be defined by an infrared signal from any remote control.

As shown in FIG. **10**A, when the user presses a button on the remote control **206**, an infrared signal is transmitted. The gateway **110** receives the infrared signal and performs the requested action (e.g., a channel change) on the selected source/device. When the gateway **110** receives the infrared signal, the content capture engine **162** performs a capture and/or analysis of one or more frames of the video signal that are presented on the television follow the trigger event. Again, the content identification rules define the number of video frames to analyze, what analysis should occur, and the timing of the analysis.

In the example of FIG. **10**A, consider a situation where the content identification rules indicate that one frame of the video signal should be captured and analyzed every 250 ms within a frame analysis window of three seconds. Based on these rules, the gateway **110** will capture 12 frames over the three seconds (i.e., 4 frames/second×3 seconds=12 frames) that follow the trigger event. The content identification rules also indicate that each of these frames should be analyzed with the grid detection algorithm. When a grid is detected (e.g., in the form of banner **252** of FIG. **10**A), the rules then indicate that the text from the grid should be subjected to a content extraction algorithm that is unique to banners associated with the particular content provider and device (e.g., the specific type of Comcast cable box connected to the gateway). The content extraction algorithm not only identifies text within the banner, but also categorizes the identified text. For example, the content extraction algorithm may determine blocks of text as indicating particular data based on any number of parameters such as the location of the text within the banner, the font of the text, the format of the text (e.g., a time format), proximity of the text to various indicia (e.g., a program timeline, icons, etc.), and any of various other parameters that the machine learning model determines to be significant. In at least some embodiments, the categorization portion of the content extraction algorithm is a machine-learned algorithm. In other embodiments, the categorization portion is a human-programmed algorithm.

In addition to identifying text, and classifying the text, the content identification rules further indicate when the content identification process should be terminated (e.g., prior to the full three second period). For example, in the embodiment of FIG. **10**A, the content identification period may terminate when either (1) two consecutive video frames are analyzed and identify the same content, or (2) a specific additional trigger event occurs (e.g., a new channel change signal from the remote control). When content is identified, the data may be saved in the internal memory of the gateway **110** and/or transmitted to the remote server **310**. It is also possible that the rules may instruct the gateway to discard (and/or do not transmit) the identified content the content was not presented on the television for a threshold period of time (e.g., a subsequent channel change signal was received within ten seconds).

When the content identification rules are executed in the example of FIG. **10**A, no grid may be detected for the first few frames that are captured following the trigger event (e.g., it may take 1 second for the content banner **252** to appear on the television **200**). Accordingly, the content identification process does not occur for the frames captured and analyzed during second one of the frame analysis window. However, if the banner **252** then appears during second two of the frame analysis window, the gateway detects the occurrence of the banner **252**, and the content identification rules applies a content extraction algorithm to the banner. The content extraction algorithm not only recognizes text, but also categorizes the text in order to determine specific data taken from the banner. For example, in FIG. **10**A, it may be determined that the text "Criminal Minds" is indicative of a program name and the text "2007" is indicative of a year when the program first aired. In this case, when data from two (or more) consecutive frames are identical, the rules instruct the gateway to terminate the analysis process, and the data associated with the identified content is saved and/or transmitted to the remote server. Because the data associated with each set of content identification rules is slightly different, it will be recognized that the data packages from different rule sets will also be different. Various examples of such data packages are described in further detail hereinafter with respect to FIG. **21**A under the "Data Packages" subheading.

While FIG. **10**A provides one example of an external trigger event and content identification rules associated therewith, it will be recognized that numerous variations of such rules and trigger events are possible. For example, in at least one embodiment, when an infrared signal is detected, the gateway **110** performs a media capture of the current incoming media, and all captured frames are stored in the gateway's memory without any analysis. Thereafter, the captured frames are transmitted to the remote server/cloud for analysis. In at least some embodiments the rules call for capture and/or analysis of all identified video frames within a frame analysis window, even if there is no useful information in them. For example, in the case when frame captures occurs because a user changes the volume level with his remote control, the captured frames may or may not contain useful information. On the other hand, when a user changes the channel, the captured frames have a high probability of containing useful information such as the program name, channel number, network name or other useful information.

Time-Based Frame Captures

FIG. **10**B illustrates a second exemplary external trigger event defined simply by the passage of time. The trigger event is included with a particular set of content identification rules associated with a particular game console (e.g., a Sony PlayStation). In the example of FIG. **10**B, the content identification rules indicate that a screen should be captured and/or analyzed every ten seconds. Accordingly, video frames are captured for content **410** displayed on the television **200** at time 10:05:20, content **420** displayed on the television **200** at time 10:05:30, and content **430** displayed on the television at time 10:05:40. Subsequent video frames are also captured every ten seconds for the entire time that content from the game console is displayed on the television (e.g., frame captures every ten seconds for an hour or other time that the game console is in use).

The content identification rules identify specific in-depth content analysis procedures to be performed on each screen captured. As noted previously, in-depth content analysis is often based on machine learning models. For the video game console of FIG. **10**B, the content identification rules may call for machine-learned algorithms, such as text recognition, logo/trademark recognition, character recognition, object identification, etc. These machine-learned algorithms are run sequentially or in parallel for each captured frame, as defined by the content identification rules. In some instances, these machine-learned algorithms are complex and require significant processing power. Accordingly, for these algorithms, the captured video frames are transmitted

to the cloud/remote server **310** for further processing. In any event, the content data returned from the local and/or remote content identification engines provides valuable information concerning the particular content being played on the television. For example, in the example of FIG. **10**B, the content identification engine may determine that the user is playing the "Call of Duty: Advanced Warfare" game. As another example, in some instances the content identification engine may simply identify video game content in a generic manner, such as: "video game/war game." Again, the data collected based on the content identification rules is assembled into a unique data package and saved to the gateway **110** and or transmitted to the cloud/remote server **310**.

While FIG. **10**B illustrates one example of a time-based external trigger event applied on one set of content identification rules, it will be recognized any number of additional time-based trigger events are possible. For example, in at least one embodiment, a time-based trigger event could require a frame capture every one minute with programming from a cable box, if no other trigger event occurred within the past minute. In yet another embodiment, a time-based trigger event could occur every five seconds with OTA content in an attempt to capture all advertising content displayed while a panelist is watching a broadcast channel.

Content Grid Detection

FIGS. **10**C and **10**D illustrates a first exemplary frame trigger event based on content grid detection, wherein the content grid is provided in the form of a content banner **252**. The trigger event is included with a particular set of content identification rules associated with a particular cable box or satellite box (e.g., Comcast cable box, Direct TV satellite box, etc.; the term "set-top box" as used herein refers to either a cable box or a satellite box). In the example of FIGS. **10**C and **10**D, the content identification rules analyze each and every frame of video from a video signal and determine whether a content banner **252** is present on the television **200** (as noted on the left side of FIG. **10**C) or is not present on the television **200** (as noted on the right side of FIG. **10**C). When the content banner **252** is present, the content identification engine **164** performs further processing on the identified frames in order to identify the content provided within the banner (in a similar manner to that described above with reference to FIG. **10**A).

FIG. **10**D shows an exemplary log file **450** of the gateway **110** based on the analysis of a single video frame (and particularly a video frame with a content banner, such as that shown in FIG. **10**A). The log file illustrates the steps taken by the gateway **110** when implementing a set of content identification rules, and particularly those associated with extracting programming data from a content banner. At line **451**, the log file **450** shows that the gateway was reviewing video frames and waiting for a content grid to appear in one of the frames. At line **452**, the log file **450** shows that a content grid in the form of a banner was detected in one of the frames. At line **453**, the log indicates that further processing confirmed the presence of the content banner **252** within the frame. Accordingly, a trigger event is shown in lines **452** and **453** by the detection of a content banner. This trigger event resulted in further processing on the frame, as noted in lines **454**-**458** of the log **450**, in order to identify the content associated with the frame. In particular, at line **454**, the log **450** indicates that the process of extracting text from the grid was performed (e.g., via a text recognition tool such as OCR). At line **455**, the text categorization process identified the name of the program as "Criminal Minds (2007)". At line **456**, the text categorization process identified the network as "ion HD". At line **457**, the text categorization process identified the channel number as "**531**". Then, at line **458**, the log **450** indicates that a data package with this information is assembled and transmitted from the gateway **110** to the remote server **310**. Finally, at line **459**, the log **450** shows that the gateway returned to reviewing video frames for another trigger event in the form of detection of another content banner. This process of extracting text from a grid and categorizing or otherwise identifying such text is one example of a content extraction algorithm defined by a set of content identification rules.

While FIGS. **10**C and **10**D illustrate a frame trigger and related processing based on the detection of a content banner, it will be recognized that other forms of content grids and subsequent processing are also possible. For example, as shown in FIG. **10**E, content grids may also take the form of content mosaics **352**. Content mosaics **352** include numerous blocks **354** of content (or content sources) that are simultaneously presented on a screen. The blocks **354** may be rectangular or any other shape, but they are selectable by a viewer in order to lead the viewer to desired content for presentation on the screen. Using a remote control, the user is able to move to any block on the mosaic by moving a selector. The current position of the selector (i.e., the block that the selector is current associated with) is highlighted in some way for the viewer. For example, the current block associated with the selector may be highlighted by an enhanced border, enhanced shading, an enlarged block relative to neighboring blocks, or any of various other highlighting techniques. As the user moves the selector from block to block, each selected block is highlighted. When the user wishes to view the content identified in the highlighted block, the user selects the block by taking an appropriate action, such as selecting an enter button on the remote control (e.g., the "OK" button).

The gateway **110** is configured to identify content presented on the television screen based on a user's manipulation of a content mosaic **352**. FIG. **10**F shows an exemplary log file **460** of the gateway **110** based on the analysis of a single video frame, and particularly a video frame with a content mosaic **352**, such as that shown in FIG. **10**E. The log file **460** illustrates the steps taken by the gateway **110** when implementing a set of content identification rules, and particularly those associated with extracting programming data from a content mosaic. At line **461**, the log file **460** shows that the gateway was reviewing video frames and waiting for a content mosaic to appear in one of the frames. At line **462**, the log file **460** shows that a content grid (in the form of a mosaic) was detected in one of the frames. At line **463**, the log indicates that further processing confirmed the presence of the content mosaic **352** within the frame. Accordingly, a trigger event is shown in lines **462** and **463** by the detection of a content mosaic. This trigger event resulted in further processing on the frame, as noted in lines **464**-**468** of the log **460**. In particular this further processing identified content selected from the mosaic by the viewer. At line **464**, the log **460** indicates that the process of extracting text from the mosaic was performed. At line **465**, the log indicates that the user selected one of the blocks of the mosaic. At line **466**, the log indicates that the text from the selected option was extracted. At line **467**, the text identification tool identified the selected option (e.g., "TV", "Game of Thrones", "Friends: The One Where Everybody Finds Out"). Then, at line **468**, the log **460** indicates that a data package with this information was assembled and transmitted from the gateway **110** to the remote server **310**. Finally, at line **469**, the log **460** shows that the gateway

returns to reviewing video frames for another trigger event in the form of detection of another content banner.

As illustrated in the foregoing examples, the gateway **110** maintains a log of various screens presented to a user and various selections made by the user. This log in combination with the various content identification rules allows the gateway **110** to actually track a user's path/journey as they make their way through various content options, including input sources, menus, mosaics, and any of various other options presented on the television screen. The information on such paths is extremely valuable to content providers because it can help content providers understand how to most effectively deliver content to consumers.

FIG. **10**G illustrates an example of such a log **470** showing a user's path to selecting and watching a movie. As noted at the top of FIG. **10**G, the user has selected the HDMI**2** option for input to the television **200** from the gateway **110**. In this case, the HDMI**2** option is a Roku device. As noted in line **471**, the user's journey began at the main menu of the Roku device. As noted in line **472**, the user then selected the Disney+ App from the main menu of the Roku device. Line **473** shows that the user next browsed the main menu of the Disney+ App. As noted in line **474**, the user then selected the Marvel category from the Disney+ menu. At line **475**, the user browsed the "Marvel" menu. At line **476**, the user selected the "Iron Man" category from the "Marvel" menu. As noted in line **477**, the user chose the "Iron Man 3" movie. Then at line **478**, the movie started. This simple example shows how a user's path through content may be tracked. The gateway can be configured to track this path at any level of detail, including for example, user movement through various input sources, menus, and blocks of a content mosaic. With this information in hand, the most advantageous positions within menus, mosaics, and other content display platforms may be determined.

Detection of Network Logos

FIGS. **10**H and **10**I illustrate another exemplary frame trigger event based on detection of network logos **258**. Once again, the trigger event is included with a particular set of content identification rules associated with a particular input source (e.g., Comcast cable box). In the example of FIGS. **10**H and **10**I, the content identification rules analyze multiple frames per second (e.g., 30 frames per second) from a video signal and determine whether a network logo **258** is present on the television **200**, or is not present on the television **200**. While detection of network logos is a machine-learned process, this processing can typically be performed on the gateway because of the limited number of network logos currently in use (e.g., less than one thousand). The network logos that may be detected by the gateway **110** include the network logos that appear on any of various programming content, including that delivered by cable/satellite television providers (e.g., AT&T, Comcast, DirectTV etc.), OTT providers (e.g., Netflix, Amazon Prime, Hulu), video game console brands and game titles (e.g., Xbox, PlayStation), and various other providers.

Advantageously, the content identification rules may implement the network logo detection algorithm in various situations. Primarily, the presence of the network logo indicates the currently tuned network (or OTT provider, video game console, etc.). Identification of a network logo can improve the efficiency and accuracy of content detection by providing confirmation that other identified content is correct (e.g., that the content extracted from a grid is correct). Furthermore, the absence of a network logo in the transmission may also be valuable. For example, the absence of a network logo could mean that a television advertisement/commercial is currently being broadcasted (logos are not typically present in commercials). Accordingly, the network logo detection algorithm may serve as a trigger event to run other content detection algorithms that are more associated with advertising (e.g., see the discussion below under "Brand Detection"). Alternatively, the absence of a network logo may indicate other activity, such as the user navigating a content grid, the user browsing other services provided by the cable operator, or that the cable set top box is on standby mode or displaying a screen saver. Thus, it will be recognized that detecting logo absences is also an important process in order to improve the efficiency and accuracy of the content recognition.

FIG. **10**I shows an exemplary log file **480** of the gateway **110** based on the analysis of a single video frame (and particularly a video frame with a network logo **258**, such as that shown in FIG. **10**H). The log file illustrates the steps taken by the gateway **110** when implementing a set of content identification rules that includes determining the existence of a network logo **258**. At line **481**, the log file **480** shows that the gateway was reviewing video frames and detecting the existence of network logos in each frame. At line **482**, the log file **480** shows that a network logo was detected in one of the frames. At line **483**, the log indicates that further processing identified the logo as the "FOX SPORTS" logo. At line **484**, the identified network logo was included in a data package and transmitted from the gateway **110** to the remote server **310**. At line **485**, the gateway continued reviewing frames for presence of a network logo. At line **486**, a frame was identified that did not include a network logo. At line **487**, the absence of a network logo was noted and transmitted to the remote server. As noted above, the absence of a network logo in a video frame could itself serve as a trigger event, causing the content identification rules to perform subsequent processing, such as analysis of advertisements.

Real-Time Scene Change Detection

FIG. **10**J illustrates another exemplary frame trigger event based on detection of scene changes. Once again, the trigger event is included with a particular set of content identification rules associated with a particular input source (e.g., Comcast cable box). In the example of FIG. **10**J, the content identification rules analyze all frames of the video signal and determine whether a scene change has occurred. A scene change may indicate a number of different events, including a transition to advertising, a channel change, or simply a new scene within a program. Advantageously, the machine-learned scene change algorithm is capable of identifying a scene change, and the content identification rules are configured to use the scene change as a trigger event for further processing (e.g., analyze for advertisement, new channel info, etc.).

The scene change algorithm may be configured to detect a scene change in a number of different ways. For example, the algorithm may monitor a series of consecutive frames and look for some threshold number of consecutive blank frames (e.g., three frames) within the series. In FIG. **10**J, a series of consecutive frames **280** is shown with five consecutive blank screens **281** included within the series **280**. The content identification rules detect this series of blank screens **281** as a trigger event to implement an advertisement identification algorithm which includes several in-depth machine processes, such as face recognition and/or brand logo recognition.

When a scene change is detected, the gateway immediately stores a timestamp of the event, and additional processing begins as defined by the selected content identifi-

cation rules. When a brand is detected within the video frames following a scene change, the machine-learning model appends the scenes associated to that particular television ad, in order to obtain the final duration of the ad, start and end time. Other exemplary elements that may be detected following a scene change include landmark detection, persons detections, object detections, etc. A text version of the detected items may be stored in the database and incorporated into the data package output from the content identification rules. In at least some embodiment, the audio associated with a given advertisement may be captured from the HDMI signal and converted to text for storage in the local or remote database. This allows for further identification of advertisements in the event there is some question about what particular ad was presented on the television (e.g., the Coca-Cola ad with the polar bear, or the Coca-Cola ad with the puffin) when an advertisement occurs.

Another advantageous feature of the scene change detection algorithm is the ability to assign a length of time to the advertisement. For example, by reviewing a series of consecutive frames, the gateway **110** could register that a television commercial for Coca Cola ran from 11:23:30 to 11:24:00.

The scene change detection algorithm may also be used with other algorithms to specify a particular event (e.g., type of content change) occurred following a scene change. For example, if the frames immediately following a scene change do not include a network logo, the content identification engine may determine that a commercial is being played, and any of various advertisement identification algorithms may be run. On the other hand, if the frames immediately following a scene change still include a network logo, it is unlikely that the scene change was to a commercial, and the advertisement identification algorithms need not be run.

Brand Detection

The machine learning models further include algorithms configured to detect brand/trademark presences within content (e.g., Coca-Cola, Pepsi, Toyota, Ford, etc.). The detection of brands may be as simple as extracting text from a frame and identifying a particular string of text as a known brand. However, more complex machine-learned algorithms may also be used to identify brand logos. For example, in the example of FIG. **10**K, the machine-learned brand recognition algorithm may be configured to not only extract the text "Coca-Cola" **283** from the video frame, but may also be configured to recognize the ribbon **285** as a brand logo for Coca-Cola. With certain rule sets, brand detection may be used as a frame trigger (e.g., to indicate that a commercial is airing). However, in most rule sets, brand detection is used for more in-depth content analysis following another trigger event. For example, if a detected scene change (or alternatively, the absence of a network logo) indicates that a commercial is occurring, various in-depth brand detection algorithms may be applied to the video frames following the scene change as part of an advertisement identification algorithm. In addition to identifying brands, the advertisement identification algorithms may also include other machine-learned algorithms that detect other components of a commercial. For example, the advertisement identification algorithms may indicate that a particular Coca-Cola commercial included people, a beach, and a dog. This identified content is of great value in determining specific advertising content that was viewed by specific panelists at a specific time.

In view of the above, it will be recognized that many of the trigger events associated with FIGS. **10**C-**10**K are frame triggers associated with internal machine learning models and algorithms. While some of these algorithms that that provide the frame trigger (e.g., grid detection) implement relatively simple machine-learned algorithms, others are much more complex (e.g., face recognition) and require significant processing power. Thus, while each of the machine-learned algorithms described above may be used as trigger events, the more complex machine-learned algorithms are more appropriate for in-depth content analysis than as frame triggers. Accordingly, it will be appreciated that different rule sets within the gateway will implement the machine learning models and algorithms differently. For example, one rule set may implement a logo recognition algorithm as a trigger event, while another rule set may only implement the logo recognition algorithm following a trigger event.

Changes in Signal Parameters of an OTA Content

The content identification rules for over-the-air (OTA) content is generally distinct from those used with any other input sources. When a user is watching OTA television, the digital tuner is constantly reading the incoming digital signal coming from the antenna. OTA transmissions inherently include specific content information such as network name, channel number and program name in their signal. Whenever the gateway **110** detects a change in these parameters (i.e., the content information in the OTA transmission), the gateway determines that the user has changed a channel. At that time, the gateway reads the parameters and registers them. In this way, the OTA transmission itself can serve as an external trigger (i.e., a non-frame trigger) causing the gateway to record new information each time the parameters of the OTA transmission changes. However, it will be recognized that the content identification rules for OTA content may also include any of various additional trigger and/or machine-learned algorithms discussed above. For example, the frames of an OTA transmission may be periodically reviewed (e.g., every five seconds) to determine if a network or brand logo is present. Alternatively, the frames of OTA content may be continually reviewed to determine whether a scene change occurred.

Machine Learning Modules and Training

As noted above, the gateway **110** makes use of numerous machine-learned algorithms (which may also be referred to herein as "machine-learning modules") within the various content identification rule sets. Each of these machine learning modules is trained remote from the gateway to perform a particular task. The trained modules are then transmitted from the cloud to the gateway **110** and stored as machine learning modules within the content identification engine **164**. The content identification engine **164** implements these modules and provides various forms of content identification data as an output.

Each of the machine learning modules is trained to perform a particular task. For example, the content grid identification module may be trained to detect the occurrence of a content banner (or content grid) within a video frame. As another example, the network logo identification module may be trained to detect the occurrence of network logos in a video frame. In any event, the training process includes first creating a training set comprising a plurality of video frames. The training set includes a first plurality of video frames that include the occurrence of defined content (e.g., a content grid, network logos, text within a content grid, etc.) and a second plurality of video frames that do not include the occurrence of the defined content (e.g., no content grid, no network logos, etc.). The defined content may be, for example, any of the above defined frame triggers

(e.g., content grids, network logos, brands, scene changes, etc.). The training set is then used to train a machine-learned algorithm configured to detect the occurrence of the defined content within a video frame.

The machine-learning modules may be trained as neural networks with various layers (e.g., input layer, hidden layers, output layer) and nodes within each layer, as well as various weights applied to the nodes within each layer based on the training. It will be recognized that any number of different parameters and weights may be assigned to the various nodes in order to arrive at the probabilistic output. Moreover, the weights and nodes may be adapted over time as iterative training occurs. Because the content data output from the machine learning engine is actually a high probability prediction of content, the reliability of the identified content improves over time with additional learning. This additional learning typically occurs remotely and is transmitted periodically to the gateway **110** in order to update the various machine learning modules.

The output of the machine-learned algorithm indicates the occurrence or non-occurrence of the defined content within the video frame. The output of a machine-learning module within a given rule set may serve to generate data related to the media content itself (e.g., brands, logos, etc.), and/or may serve as a trigger event for implementation of another machine-learning module (e.g., the existence of a content grid).

Various machine-learning modules within the gateway **110** may be utilized to perform a first round of content recognition on the captured media. If the gateway's content identification rules are able to resolve the content with enough accuracy, the generated content data is packaged and transmitted to a remote location where it is stored in a cloud-based database. On the other hand, when the gateway's content identification rules do not resolve the content with sufficient accuracy (e.g., there are missing or unknown pieces in the data package), the data package and any associated video frames may be transmitted to a remote location for further processing. This remote processing typically includes much more powerful machine learning modules that are not efficiently run at the gateway. For example, face recognition, character recognition, advanced game recognition modules, etc. may all be more efficiently performed with remote cloud-based software. The output of these modules may then be used to complete or supplement any data packages generated using the gateway's content identification rules.

In view of all of the foregoing, it will be appreciated that the gateway includes various machine learning models that perform real-time detection of elements included in the frames of an incoming video signal. Models are initially trained using cloud computing infrastructure, which provides high computing powered. Once the models are trained, they are deployed into the gateway **110** for it to perform recognition on the incoming video frames. Additional remote machine learning modules may be applied to captured video frames that are transmitted to the remote server **310** or other remote locations.

Active and Passive Panelist Registration

As noted above, the gateway **110** is configured to register panelists who are determined to be watching the television **200** connected to the gateway **110** at the time of registration. The gateway **110** is also configured to de-register panelists after some period of time when it is determined that the panelist is no longer watching the television **200**. When a panelist is registered, that panelist is associated with the media content presented on the television during the period of registration. In particular, when content is analyzed in order to identify the content (e.g., using the methodologies discussed in the previous section), all the panelists registered with the gateway **110** at the time the content is presented on the television **200** are also associated with the data that identifies the content. Therefore, the data generated by the gateway **110** not only identifies content presented on the television, but also identifies all panelists who watched/consumed the content.

Registration of panelists at the gateway occurs by either active or passive registration. Active registration requires conscious actions from at least one panelist in order to register the panelists who are currently watching the television **200**. In at least one embodiment, active registration of panelists occurs by the user pressing one or more buttons representing the panelists to be registered. These buttons may be presented in several ways, including physical buttons on the remote control **206** for each panelist, physical buttons on the gateway housing **112** for each panelist, and virtual buttons overlaid on the television screen **200** when a registration menu is activated.

In a first embodiment, the remote control includes a dedicated button for registration of each panelist. For example, as shown in FIG. **11**, the remote control **206** for the gateway **110** includes a series of differently colored buttons **208** positioned along the bottom of the remote control **206**. Each of these buttons **208** is associated with one of the panelists **204** when the gateway **110** is initially set up for the household **202**. For example, if the buttons **208** include a red, green, yellow and blue button, the red button may be associated with a first adult female, the green button may be associated with a first adult male, the yellow button may be associated with a first child, and the blue button may be associated with a second child. Thereafter, when the television is on and one of these buttons is pressed, the panelist associated with that button is registered with the device at that time. An indication of panelist registration may then be overlaid on the television screen (e.g., an avatar for the panelist may be presented on the screen along with a welcome message, as described in further detail below), or may appear on the gateway display **152**. When the panelist de-registers, an indication of de-registration may also be overlaid on the screen (e.g., an avatar for the panelist may be removed from the screen and a good-bye message presented).

The buttons **208** may be configured in any of various ways to register and de-register panelists. For example, in one embodiment, each of the buttons **208** is a toggle switch such that pressing a button the first time registers the associated panelist, and pressing the button a second time de-registers the associated panelist. In another embodiment, the number of times the button is pressed within a short period of time registers or de-registers the associated panelist (e.g., one press within two seconds registers the associated panelist, and two or more presses within two seconds de-registers the associated panelist). Panelists effectively use the buttons **208** by registering when they enter a room and begin watching media presented on the television **200**, and then de-register when they leave the room or otherwise stop watching TV. Again, during a panelist's viewing session, all detected/captured content information will have the panelist's identification and current timestamp attached to it, in order to associate the panelist, to the viewed content.

While the foregoing paragraphs describe one exemplary embodiment of active registration, it will be recognized that other forms of active registration are contemplated. For example, active registration may occur using physical but-

tons provided on the gateway or virtual buttons provided on the television screen when a user enters a registration routine (e.g., a routine that may be called up using a physical button on the remote or virtual button in another menu). As yet another example, active registration may occur using voice commands provided to the gateway **110** (e.g., "Hey Google, Adam is watching television".)

In addition to active registration, the gateway **110** also provides for passive registration of panelists. Passive registration occurs automatically without any conscious effort by the panelist to register. The gateway **110** is generally configured to perform passive registration by detecting use proximity to the gateway **110** (and thus the proximity to the television **200**). In at least one embodiment, passive registration occurs by detecting the signal strength at the gateway **110** from mobile devices that are in communication therewith and associated to particular panelists. The mobile devices may be provided (i) by mobile computing devices such as a smartphones, tablets, watches, or other mobile devices configured with Wi-Fi communications capabilities, and/or (ii) by wearable devices with short range wireless communications capabilities such as dedicated watches or bracelets with Bluetooth communications capabilities, or any of various other devices with Bluetooth communications capabilities, such as earbuds.

Mobile computing devices within a household are registered with the gateway **110** (i.e., identification data is shared and the device is configured for automatic connection to the gateway) at the time of gateway setup (or any time thereafter). Registrations of smartphones and smartwatches with the gateway are particularly advantageous because these mobile computing devices are typically carried by the panelist at all times. In any event, the unique identifier/MAC address of a mobile computing device that is associated with a panelist is stored in the panelist data **172** of the gateway **110**. Each panelist's mobile computing device is configured to automatically connect to the same Wi-Fi network as the gateway **110**. As discussed in further detail below, the gateway's Wi-Fi chipset **125** allows the gateway **110** to either (i) serve as a router and establish a new Wi-Fi network, or (ii) operate in a sniffer mode in order to detect network traffic within the existing Wi-Fi network. In either case, the gateway constantly scans for MAC Addresses from devices communicating over the Wi-Fi network. When the gateway recognizes the MAC Address of a mobile device associated with a panelist, the signal strength (e.g., RSSI) of that mobile device is recognized to determine the proximity of the panelist to the gateway. When the signal strength from the mobile device is greater than a threshold strength, the panelist is determined to be in proximity to the gateway **110** and the television **200**, and the panelist is registered at the gateway. All identified presented on the television **200** is then associated with the panelist during registration. When the signal strength from the mobile device is less than the threshold, the panelist is determined to be outside proximity to the gateway **110** and television **200**, and the panelist is not registered with (or is de-registered from) the gateway **110**.

With reference now to FIG. **12**, a table **1200** of WPA handshakes collected at the gateway **110** is shown. The table includes a list of MAC addresses associated with WPA handshakes between various mobile devices and the wireless access point (e.g., provided at the gateway **110** or household router). The BSSID column **1210** shows the unique identifier/MAC address for a number of devices communicating over the wireless network. Other information is also shown in the table **1200**, including a signal strength column **1220** which provides a numerical value representative of the signal strength of the mobile device at the gateway **110**. When the signal strength is greater than a threshold value (e.g., 25), the panelist associated with the mobile device is determined to be in proximity to the television **200** (e.g., 25 feet), and the panelist is registered at the gateway **110**. When the signal strength is less than the threshold, the associated panelist is determined to not be in proximity to the television **200**, and the panelist is not registered (or is un-registered) at the gateway **110**. Advantageously, the threshold signal strength may be different for each gateway **110**, depending on the size of the room where the gateway is installed. For example, in a first home, the gateway may be installed in a room that is 20 ft×20 ft, and in a second home the gateway may be installed in a room that is 30 ft×30 ft. Because of this, a panelist determined to be 25 feet away from the gateway in the first home is unlikely to be in proximity to the television, while a panelist determined to be 25 feet away from the gateway in the second home is likely to be in proximity to the television. Accordingly, when the gateways are initially configured in these two homes, the technician or user may make the threshold in the first home to be less than the threshold in the second room.

FIG. **13** is a flowchart summarizing the above-described method **1300** of registering a panelist based on the signal strength of a MAC address. The method begins at step **1310** when the gateway **110** is turned on and the gateway joins a household Wi-Fi network (or serves as a router therein). At step **1320**, the method continues by conducting MAC address polling via the Wi-Fi beacon. At step **1330**, a list of detected MAC addresses is analyzed (e.g., similar to that of FIG. **12**). At step **1340**, a determination is made whether a MAC address associated with one of the panelists is in the lists. If a MAC address associated with a panelist is in the list, the method continues to step **1350**, and the power signal level associated with the MAC address is analyzed by comparing it to a threshold. As step **1360**, if the power level is greater than the threshold, the associated panelist is considered to be in proximity to the television. On the other hand, if the power level is less than the threshold, the associated panelist is considered to be outside proximity to the television. At step **1390**, when the panelist is determined to be in proximity to the television, the panelist is registered and an avatar for the panelist is shown on the television. However, if the panelist is not in proximity to the television, the method moves to step **1370**, and a determination is made whether or not the panelist is currently registered with the gateway. If the panelist is not currently registered at step **1370**, the method returns to step **1320** and continues to poll for MAC addresses. However, if the panelist is currently registered at step **1370**, the method continues to step **1380**. At step **1380**, the panelist is de-registered at the gateway, and no avatar for the user is shown on the television.

As noted previously, in addition to passive registration based on the proximity of Wi-Fi-enabled mobile computing devices to the gateway, passive registration may also occur based on proximity of wearable electronic devices with short range wireless communications capabilities (e.g., Bluetooth) to the gateway. FIG. **14** shows an example of dedicated wearable electronic devices in the form of bracelets **1410** configured to be worn on the wrist and pendants **1420** configured to be worn around the neck or carried in the pocket of the panelist. Dedicated wearable devices are typically reserved for use by children or the elderly who do not own a smartphone or other mobile computing device capable of communicating with the household wireless network. However, dedicated wearable devices **1410**, **1420**, may also be used by adults who do not own a smartphone or

do not regularly carry their smartphone around the house. Other examples of wearable electronic devices include headphones, earbuds, or other wearable speaker devices (e.g., iPods), with short range wireless communication capabilities. These devices are increasingly being carried by individuals at all times, and may be used to passively register panelists with the gateway **110**.

Registration of panelists carrying wearable electronic devices is similar to registration of panelists with Wi-Fi-enabled mobile computing devices. However, instead of monitoring signal strength, the Bluetooth chipset **123** of the gateway **110** simply polls for Bluetooth signals from various wearable electronic devices. In particular, the gateway **110** continually sends a polling signal to ask whether any wearable devices are receiving Bluetooth signals from the gateway. The strength of the polling signals is such that only wearable electronic devices within a certain range (e.g., 25 feet) will receive the signal. The strength of the polling signal may be adjusted within the gateway **110** (e.g., by a technician via the gateway's configuration interface) in order to provide the proper signal range. When a response to the polling signal is received from one of the wearable electronic devices, the gateway recognizes the wearable device, and the associated panelist is registered at the gateway **110**.

FIG. **15** is a flowchart summarizing the above-described method **1500** of registering a panelist based on Bluetooth communications with a wearable electronic device. The method begins at step **1510** when the gateway **110** is turned on and the gateway Bluetooth chipset **123** is powered up. At step **1520**, the method continues with the Bluetooth transceiver sends Bluetooth polling signals, and listens for responses from any Bluetooth devices that are within range of the polling signal. At step **1530**, a determination is made whether any confirmation signals have been received from wearable devices in proximity to the gateway **110**. If a confirmation signal is received from a wearable device, the method continues to step **1540** where the panelist associated with the wearable device is determined to be in proximity to the television. In this case, the panelist is registered at the gateway **110** and an avatar for the panelist is displayed on the television. At this time, the registered panelist is associated with all identified content presented on the screen until the panelist is subsequently de-registered. On the other hand, if no confirmation signal is received from the wearable device, it is determined the panelist associated with the wearable device is not in proximity to the television, and the method moves on to step **1550**. At step **1550**. If the panelist is not currently registered at step **1550**, the method returns to step **1520** and simply continues to poll for Bluetooth communications from wearable electronic devices. However, if the panelist is currently registered at step **1550**, the method continues to step **1560** where the panelist is de-registered at the gateway **110**, and no avatar for the user is shown on the television. From this moment, the previously registered user will no longer be associated with any identified content presented on the television until the panelist is re-registered.

In view of the foregoing described processes of active and passive user registration, it will be recognized that registration of panelists may occur in any of several forms, including passive registration only, active registration only, or some combination of passive and active registration. In general, active registration and de-registration is only necessary in cases where a panelist is not carrying his or her smartphone or other mobile electronic device (e.g., wearable device), or if the mobile electronic device has run out of battery power. Passive registration and de-registration occurs automatically when the user is carrying a fully powered mobile electronic device. In some embodiments, a warning message is shown prior to automatic de-registration of a panelist (e.g., "It appears that Adam has left the room; please press Adam's registration button on the remote control if this is incorrect.") These warning messages are designed to guard against de-registration when the user is actually still in the room but appears to have left the room for some reason (e.g., a panelist may appear to have left a room because his or her phone died, a child or other third party carried the user's smartphone out of the room, the user turned off the Wi-Fi on the phone, etc.). In further embodiments, when the system **100** detects that active and passive registration are often inconsistent, a message may be displayed on the television asking the panelist to take care to comply with registration protocols. For example, if a panelist repeatedly performs the active de-registration procedure but leaves his or her smartphone in the same room as the gateway **110**, a message may be sent asking the panelist to keep the phone on his or her person, or find a different charging station for the phone.

While exemplary methodologies for active and passive registration and de-registration are described herein, it will be recognized that various additional devices and methodologies may be used in addition to or in lieu of those described herein to confirm registration or de-registration of a panelist. For example, in at least one alternative embodiment, the gateway **110** is further equipped with a camera and is able to perform facial recognition on individuals within proximity of the gateway.

HDMI Overlay

The gateway **110** is equipped with HDMI overlay capabilities that allow content generated by the gateway **110** to be overlaid on content from the input source and displayed on the television **200**. The HDMI overlay capabilities are provided by the content overlay engine **168** (see FIG. **2**A), which is configured to overlay legends, messages, icons, avatars, and other additional content/information on the media content provided to the television via the cable connected to the HDMI out port **133**. The HDMI overlay engine **168** may be configured to overlay different types of information on the television at different times during operation of the gateway.

One instance in which the content overlay engine **168** overlays information on the media content is during panelist registration and de-registration. As described above, a panelist who is associated in the gateway **110** with a properly configured mobile electronic device (e.g., a smartphone or wearable electronic device) will be registered when the gateway detects that the mobile electronic device is in proximity to the gateway **110**. Each panelist in the household is associated with a unique avatar. When a panelist is registered, the gateway **110** display the panelist's avatar over the content presented on the television for some period of time along with a welcome message to the newly registered panelist. When the panelist is de-registered, the gateway **110** displays a good-bye message and removes the panelist's avatar from the screen.

FIG. **16** shows an exemplary television **200** with a plurality of avatars **270** overlaid on the program content **254** presented on the television screen. Six avatars **270** are overlaid on the program content **254** in the example of FIG. **16**, indicating that six panelists are currently registered and are being associated with the program content **254** within the gateway **110**. The six avatars **270** are all included in a single row across the top left side of the television **200**. Avatars **270**

for the currently registered panelists are all temporarily displayed on the television for a short period of time when a panelist registers or de-registers with the gateway **110**. For example, the avatars **270** may be shown for five to ten seconds after an additional panelist registers with the gateway **110**. After the short period of time, the avatars **270** disappear and only the program content **254** is shown on the television screen. Alternatively, in at least one embodiment, the avatars **270** are displayed in full color during the short period of time, but after expiration of the short period of time the avatars are muted (e.g., shown as dim colors, translucent, minimized, ghosted, replaced with small substitute icons) or completely hidden.

In the example of FIG. **16**, the Jerry Smith recently entered the room where the television **200** is located carrying his smartphone. At this time, the power signal level associated with the MAC address for his smartphone exceeded the predetermined threshold and Jerry Smith was automatically registered with the gateway **110**. This new registration prompted a welcome message **274** on the television (i.e., "Welcome Jerry"). Jerry Smith's avatar **272** was then displayed at the top of the television with the other avatars **270** for the currently registered panelists. Thereafter, during Jerry Smith's viewing session, all captured/identified content shown on the television **200** will be associated with Jerry Smith as well as any other registered panelists at the time of content identification (i.e., the data identifying the content will have the registered panelist's id and current timestamp attached to it).

After displaying the avatars **270** and welcome message **274** for a short period of time (e.g., five seconds), the welcome message **274** disappears, and the avatars **270** are muted on top of the television. For example, as shown in FIG. **17**, the avatars **270** are replaced on the screen by small icons/shapes **271** (e.g., small circles) that are each personal to one of the panelists. These icons/shapes are significantly smaller than the avatars **270** and are intended to not be overly invasive on top of the media content **254** displayed on the screen. When the icons are all the same shape, each panelist may be associated with a different color (e.g., Jerry Smith is blue and Julie Smith is red) such that the panelists may quickly identify their personal registration icon on the screen.

Following registration of a panelist, the gateway continually scans for signals associated with panelists in order to determine panelist proximity to the television (i.e., by monitoring for signal strengths in excess of the threshold from any of various wireless devices associated with the panelist). If the panelist's mobile electronic device remains in proximity to the gateway **110** (i.e., the signal strength remains in excess of the threshold), the user will continue to be registered. However, when the gateway **110** does not detect the user's mobile device in proximity to the gateway, the user is de-registered and a good-bye message (e.g., "Goodbye Jerry Smith") is displayed on the television for some period of time (e.g., 5 seconds). At this time, the user's ID and timestamp will no longer be attached to the detected/captured content information.

While the foregoing discussion related to avatars **270** and related content overlaid on the television screen was discussed in the context of passive panelist registration and de-registration, it will be recognized that avatars **270** are similarly displayed during active panelist registration and de-registration. For example, if a user enters the room without any mobile electronic device, the user may actively register by simply pressing the active registration button on the remote control and his or her avatar will be overlaid on the screen with a welcome message. In at least one embodiment, when a panelist passively registers or de-registers, a message is overlaid on the screen requesting confirmation of such registration or de-registration with the remote control. For example, if the signal strength associated with a registered panelist's mobile device is lost or is less than a threshold, a message is overlaid on the television asking the remaining panelists to actively de-register the departing panelist (e.g., "If Jerry Smith is no longer watching, please de-register him using the remote control."). In this manner, active means are used to control which panelists are registered, but passive means are used to prompt active registration or deregistration.

In yet another embodiment the gateway **110** is configured to periodically request panelist registration status. This periodic confirmation request may occur when the same panelists have all been registered for a long period of time (e.g., more than an hour). For example, as shown in FIG. **17**, a message banner **276** is shown at the bottom of the screen asking "Is everyone still watching TV." This prompts the current viewers to look at the avatars **270** or registration icons **271** shown on the screen and make sure that all the registered panelists are still in the room. The remote control may then be used to actively de-register any panelists who are no longer in the room.

In view of the foregoing, it will be recognized that the gateway **110** is configured to overlay different legends, specific messages, or any of various other additional content directly over existing media content on the television **200**. This is accomplished without the need of secondary screens or smaller displays that are hard to see. By using the television **200** as the display interface, the gateway **110** is capable of conveniently displaying any of various graphics, messages, and high-quality images to the users. As a result, the gateway **110** is equipped with numerous features that make the device highly functional and user-friendly.

Internet Activity Measurement

In addition to identifying media content presented on the television **200**, the gateway **110** is also configured to identify media content presented on any of various wireless devices within the household. To this end, the gateway **110** is configured to act as a Wi-Fi router or sniffer. Operational software for wireless networking features is retained in the memory **116** of the gateway. The wireless networking software may be retained in a separate memory of the communications module **120**, or may be retained with other instructional programs in the main memory of the gateway. In any event, this wireless software interacts with the networking hardware components (e.g., the Wi-Fi chipset **125**) in order to provide routing services, and at the same time perform network sniffing that allows the gateway to detect each panelist's Internet activity on their associated mobile device and/or computer. The gateway **110** has two different operation modes that allow it to identify and measure the online mobile device/computer activity in the households: a router mode and a Wi-Fi Sniffer mode.

When operating in the router mode, the Wi-Fi chipset **125** allows the gateway **110** to operate as wireless access point or wireless signal repeater for the household **202**. When operating in this mode, mobile/desktop clients connect directly to the gateway **110** in order to obtain an Internet connection. Thus, all the wireless traffic for the household **202** goes through the gateway **110**. The gateway **110** is configured to capture the network packets, identify media content presented on specific devices, and generally log all the Internet traffic passing through the gateway.

With reference now to FIG. **18**, an exemplary log **1800** is shown of network traffic captured by the gateway **100** when operating in the router mode. As shown in FIG. **18**, the log **1800** includes a list of data packets **1810** transferred to various mobile devices via the gateway. Each data packet **1810** includes and/or is further associated with the following information at the gateway **110**: date, time, MAC address of mobile device (or computer device), origin IP address, destination IP address, consumed URL, time to live, and user agent. This data is then stored in the memory of the gateway **110**, and/or transferred to the remote server **310** for further processing and storage.

FIG. **19** shows an exemplary flowchart of a method **1900** of capturing network traffic at the gateway **110** operating in the router mode. The method **1900** begins when the gateway **110** is turned on at step **1910**. At step **1920**, the Wi-Fi chipset **125** begins operation in the route mode and the gateway **110** broadcasts the network name (SSID) to all wireless computing devices (including mobile devices and standalone devices) within the household **202**. At step **1930**, devices within the household are joined to the wireless network provided by the gateway **110**. When each wireless device is initially joined to the network, the gateway **110** asks the user to associate one of the panelists within the household with the device. If a panelist is identified, the MAC address for the device is associated with the identified panelist within the gateway **110**. If no panelist is associated with the device, the device is simply considered a generic traffic device. As shown in step **1940**, the gateway **110** serves as the wireless access point for the wireless devices within the household, and routinely captures web traffic data, including web traffic data identifying all media content presented at the each MAC address. At step **1950**, each time web traffic is captured, a determination is made whether the traffic is associated with one of the panelist's devices. If the web traffic is associated with a panelist's device, the method continues at step **1960** and associates the identified web traffic with the panelist. On the other hand, if the web traffic is not associated with a panelist's device, the method continues at step **1970**, and the web traffic is associated to a generic network device (e.g., guest device). At step **1980**, all the web traffic collected by the gateway **110** is compressed prior to transmission to the remote server **310**. Thereafter, at step **1990**, all the filtered and compressed traffic data is sent to the remote server(s) **310** for further analysis. In particular, if the gateway **110** does not include sufficient processing power to identify media content from the network traffic, such processing occurs at the more powerful remote server **310**.

In addition to the router mode, the gateway **110** is also configured to operate in the Wi-Fi sniffer mode (which may also be referred to as the "promiscuous mode"). In this mode, the gateway **110** does not serve as a router, but instead join the household's existing wireless network (e.g., provided by the ISP's router within the household). After joining the household's existing wireless network, the gateway **110** then operates in the promiscuous mode and sniffs network packets that are passed through the network between various wireless devices and the network router. In general, the promiscuous mode causes the gateway **110** to pass all traffic/frames it receives to its microprocessor **114** (i.e., including traffic intended for other devices) for further processing, rather than passing only the traffic/frames specifically intended for the gateway **110**. In this manner the gateway **110** analyzes all network traffic, and not only the traffic intended for the gateway **110**. Data collected in the promiscuous mode includes the following for each data packet: SSID, BSSID, signal strength/power, beacons, data, channel, encryption type, authentication type, and URL.

FIG. **20** shows an exemplary flowchart of a method **2000** of capturing network traffic at the gateway **110** operating in the promiscuous mode. The method **2000** begins when the gateway **110** is turned on at step **2010**. At step **2020**, the gateway **110** joins the household's Wi-Fi network and the Wi-Fi chipset **125** begins operation in the promiscuous mode. At step **2030**, the Wi-Fi sniffer process runs, and the gateway looks for all traffic on the household's Wi-Fi network, including traffic not intended for the gateway **110**. At step **2040**, the gateway captures network traffic, and particularly URLs, consumed by/delivered to other network devices. At step **2050**, each time web traffic is captured, a determination is made whether the traffic is associated with one of the panelist's devices. If the web traffic is associated with a panelist's device, the method continues at step **2060** and associates the identified web traffic with the panelist. On the other hand, if the web traffic is not associated with a panelist's device, the method continues at step **2070**, and the web traffic is associated to a generic network device (e.g., guest device). At step **2080**, all the web traffic collected by the gateway **110** is compressed prior to transmission to the remote server **310**. Thereafter, at step **2090**, all the filtered and compressed traffic data is sent to the remote server(s) **310** (e.g., in the cloud) for further analysis. In particular, if the gateway **110** does not include sufficient processing power to identify media content from the network traffic, such processing occurs at the more powerful remote server **310**.

The foregoing process of collecting an identifying media content presented at various wireless devices is run in parallel with the other gateway processes, and in particular the process of identifying content presented on the television (e.g., see FIGS. **5A-5D** and **8-10K**) and the associated process of panelist registration (e.g., see FIGS. **12-17**). With these processes all run in parallel on the gateway **110**, it will be recognized that the gateway **110** is configured to identify content presented on all or nearly all media devices within the home, including one or more televisions **200** (with a gateway connected thereto), and any number of different wireless devices within the household. This capability allows the gateway **110** to serve as a single source capable of identifying all media content consumed within the household. Media content identified by the gateway **110** is conveniently summarized in data packages, as described below, and transmitted to the remote server.

Data Packages

FIG. **21A** shows a schematic diagram of exemplary data packages **180** generated by the gateway **110**. As shown in FIG. **21A**, the exemplary data packages include each of the following: content data packages **182**, presence data packages **184**, demographic data packages **186**, and system data packages **188**. One or more of these data packages are automatically generated following a trigger event wherein a video frame is analyzed in-depth and the associated content identified. In particular, at least a content data package and a presence data package **184** are generated following a trigger event. These data packages may be immediately transferred to the remote server **310** and/or the cloud, or may be temporarily stored on the gateway **110** for subsequent transfer. The data packages **180** may be combined or otherwise associated with each other during transmission from the gateway **110**. For example, a content data package **180** (i.e., identifying media content) and a presence data package **182** (i.e., identifying registered panelists associated with the identified content) may be automatically combined and

transmitted following a trigger event. The remote server **310** may periodically request data from the gateway, such as a system data package **186** that provides diagnostic information about the gateway **110**.

The content data packages **182** and presence data packages **184** transmitted to the remote server **310** are considered to be audience measurement "raw data". This data is further analyzed with additional processing engines at the remote server **310** (or any number of additional remote/cloud servers). The remote server **310** (or servers) apply the appropriate editing rules in order to structure the data as "clean" data for final consumption by clients. "Clean" data may simply be data that is standardized in some manner. For example, is the content data from one cable provider states a program name of "Criminal Minds (2007)", the remote editing rules may recognize that the "2007" parenthetical is a year of first showing, not the actual program name and may standardize the program name so simply be "Criminal Minds" so that it is consistent with the data collected from other cable providers. An exemplary database **190** including records/data packages of clean data is shown in FIGS. **21**A and **21**B. As noted in the figures, exemplary fields for the data package include viewership identification data (i.e., panelist identification), household identification data, content data, media source data, content provider, network data, channel data, program data, viewership room data (i.e., the room in the household where the content was viewed) viewership file, television provider, and any number of additional fields of data collected by the system **100**.

Once the gateway **110** and/or remote server **310** has finished filtering, the resulting compliant (i.e., clean) data is stored by in a separate database. This data is prepared for generating reports and be consulted through a data provisioning portal and API. Final, clean data is available to various end game customers through an authenticated API that they can connect to their own systems for further processing, such as weighting, reporting or business intelligence systems. The aforementioned distributed processing/networking approach, wherein some of the analysis and machine learning routines are performed at the gateway **110** and additional machine learning is performed at the remote server, is advantageous. In particular, much of the data can be processed without the need of the transmission of the media files over the internet, thus saving costs of bandwidth and cloud infrastructure usage. At the same time, advanced processing at the remote server **310** means that the gateway **110** does not need the same advanced processing capabilities, thus resulting in various savings with respect to cost of each gateway.

The data generated and transmitted by the cross-media measurement system **100** is integrated with Blockchain. The use of Blockchain provides a reliable mechanism for audit automation and validation. By incorporating Blockchain in all the layers of the media measurement process, the system can ensure that all registrations, transactions and data generation are traceable and secure. In its simplest form, a Blockchain can be considered to be a distributed ledger which contains the relevant details for every transaction that has ever been processed. The validity and authenticity of each transaction is protected by digital signatures (cryptography). With Blockchain, there is no central administration, and anyone can process transactions using the computing power of specialized hardware. By using Blockchain, a distributed, cryptographic and immutable database is created. The database is considered to be distributed because, unlike most databases that control who can access the information in a system, any computer in the system can access the Blockchain. This creates a system of trust since there is no centralized data. The database is considered to be cryptographic because every transaction recorded in the system is cryptographically verified to ensure its authenticity. Cryptography allows the system's components to collaborate in an automated system of mathematical trust. The database is considered to be immutable because no records can be changed or altered; only new records can be appended to the distributed database. This ensures that data cannot be modified or altered in a way that would change the data generated by the system **100**.

Remote Processing

As discussed above, the system **100** is configured to process data captured by the gateway **110** at either the gateway itself, or at one or more remote computing devices, such as remote server **310**. The remote server **310** is merely representative of any number of remote computing devices and/or cloud based software that may be utilized by the system **100**. The use of remote computing devices and cloud based software allows for increased processing power, expanded memory, and overall increased system functionality.

One example of additional functionality with cloud-based software is increase machine learning processing. In at least one embodiment, all software functions associated with content recognition and processing may run directly in the cloud, and not on physical server or even virtual servers. In this embodiment, the content recognition features work on-demand, and every time a new media capture arrives to the cloud storage, these functions automatically execute to process each piece of media individually. The training/machine learning models that power the cloud-based recognition are much more robust than the ones running locally in the gateway **110**. Although the output data is generally the same in structure, the level of training and accuracy of these models may be more advanced since the computing power in the cloud is higher than that running in the gateway itself.

In addition to machine learning, the remote processing capabilities of the system **100** also include raw data storage and processing. The remote software interprets the data generated from the machine learning process and stores all the found metadata into a high-performance big-data database. This data has not yet been processed with editing rules; it is stored directly as it arrives from the machine learning process.

The remote processing power of the system further facilitates the application of compliance rules to the data collected from the gateway **110**. Compliance rules are needed for any audience measurement process. These rules are applied to the raw data, in order to determine which households and household members are compliant and adequate to participate in the measurement for a particular day. In the present system, the compliance rules include (i) filtering of households that have a problem with the device or have disconnected it (i.e., diagnostic routines report trouble with the gateway), (ii) filtering of households that have more televisions than gateways **110** installed (i.e., all televisions of the household must be measured in order to accurately measure media consumption within the household), and (iii) filtering of household members that have more than some predetermined threshold period (e.g., 24 hours) of continuous TV viewing (i.e., thus indicating that the panelist is not actually watching the content presented). Once the processing module (e.g., at remote server **310**) has finished filtering, the resulting compliant (clean) data is stored by this module in

a separate database. This data is prepared for generating reports and be consulted through the data provisioning portal and API.

In at least one embodiment, the remote server **310** is configured to provide a web-based piece of software that allows clients to access the collected data and visualize in on a GUI. The GUI may include a dashboard visualization where all the viewing session of a particular household is displayed. This may include the person recognition information (times where a user was watching television), and a timeline that is constructed based on the time a user spent watching a specific platform, source, channel, network or program. FIG. **6** serves as an example of an exemplary dashboard for a GUI, but it will be recognized that numerous other dashboards are also possible.

In at least one embodiment, a data API is provided for clients via the remote server **310**. Clients are able to "pull" the information collected from various gateways **110** directly from the API in order to generate their own reports or to connect our data to existing systems. User administration, permission control and setup are performed by an in-house team.

Television ON/OFF State Detection

It will be appreciated based on the foregoing description that the gateway **110** is configured to identify content consumed by panelists across numerous devices, including content delivered to wireless devices **220** (e.g., smartphones, tablets, etc.) and content delivered to the television **200**. The gateway **110** is configured to continually monitor and identify content delivered to the mobile devices **110**. However, the gateway **110** is only configured to monitor and identify content delivered to the television **200** when the television itself is turned on (i.e., such that the television screen and capable of presenting content to panelists within the household). By limiting content identification to times when the television is actually turned on, content consumption is more accurately determined. Furthermore, limiting content identification times further optimizes the use of computing resources within the gateway **110** and saves data consumption associated with data transmission through the gateway's Wi-Fi or cellular network connections.

The gateway **110** is configured to determine the on/off state of the television in two ways. First, the gateway **110** is configured to determine the on/off state of the television **200** by monitoring the consumer electronics control (CEC) pin on the HDMI connection between the television **200** and the gateway **110** (i.e., at the HDMI OUT port). Second, the gateway is configured to determine the on/off state of the television **200** by monitoring power flowing to the television **200** via the gateway **110**.

AC Detection Through HDMI-CEC

CEC is a control function that lets one A/V component control another if they are connected via HDMI cables. If the television **200** is CEC-enabled, power detection can be performed through the HDMI cable connected to the HDMI OUT port **133** of the gateway **110**. By monitoring the CEC pin of the HDMI cable, the gateway **110** can detect signals indicating that the television has been turned on or turned off. As noted previously, in at least some embodiments the gateway **110** is configured to save energy and stop performing television audience measurement computing processes (including content identification and panelist registration) when the television is off. Additionally, in at least some embodiments, the gateway **110** is configured to power itself down whenever the television **200** is turned off. This is especially true in embodiments where the gateway **110** is not monitoring mobile device traffic, and is only monitoring content consumed at the television.

FIG. **22** shows a flowchart **2100** of a process used by the gateway **110** for determining television state based on CEC. The process begins with step **2110** when the gateway **110** is turned on. Thereafter, as step **2120**, the CEC pin at the HDMI output port **133** is monitored to detect whether the television is on or off. At step **2130**, a signal is received at the CEC pin. If the CEC pin indicates that the television is on, the AC status in the gateway **110** is set to "1" at step **2140**. If the CEC pin indicates that the television is off, the AC status in the gateway **110** is set to "0" at step **2150**. At step **2160**, the television status is made available for output to other components and devices via an application programming interface (API). The process ends at step **2170**, but the process is periodically repeated starting with step **2120** in order to determine television status based on the HDMI-CEC port.

AC Detection Through Gateway Power Detection

In addition to being configured to determine power via the CEC control function, the gateway **110** is also configured to monitor power delivered to the television via the AC output port **144**. To this end, the AC output port **144** of the gateway **110** includes a receptacle that receives the television's AC plug. When the television plug is connected to the AC output port **144** of the gateway **110**, the gateway is able to determine whether power is flowing to the television.

As discussed previously in association with FIG. **2**B, the gateway **110** includes an integrated power supply **150** that powers all the electronic components inside of the housing **112**. The gateway **110** also includes a TV ON/OFF detection circuit **151** that is capable of sensing that alternating current (AC) is flowing to the television's power cable through the AC output port **144**. Through an embedded API, the gateway **110** software obtains the readings from the TV ON/OFF detection circuit **151** to detect if the TV Set is turned on (i.e., alternating current is flowing to the television in excess of a threshold) or is turned off (no/low alternating current to the television).

FIG. **23** shows a flowchart **2200** of a CoreMeter process for determining television state based on AC detection using an AC sensor provided by the TV ON/OFF detection circuit **151**. The process begins at step **2210** when the gateway is turned on. Then at step **2220**, the TV ON/OFF detection circuit **151** of the gateway **110** monitors AC power flowing to the television **200** (e.g., via a current sensor). If AC power is detected at step **2230**, the process moves to step **2240** and a determination is made that the current provided to the television is within a calibration threshold. If the current is within the threshold, the process moves to step **2250**, and the gateway status of AC to the television is set to "1". On the other hand, if no AC current is detected as step **2230**, or if the AC current detected is not within the predetermined threshold at step **2240**, the process moves to step **2260**, and the gateway status of AC to the television is set to "0". At step **2270**, the television status is made available for output to other components and devices via an application programming interface (API). The process ends at step **2280**, but the process is periodically repeated starting with step **2220** in order to determine television status based on the AC to the television.

Advantageously, the two different mechanisms for monitoring power to the television **200** (i.e., CEC detection and AC detection) allows the gateway **110** to provide diagnostic information/warnings to the household when there are issues with the connections between the gateway and the television. As a first example, if the power cord of the television

200 is improperly plugged into an AC wall outlet instead of the AC output port **144** of the gateway **110**, but the CEC pin on the HDMI OUT port **133** indicates that the television **200** was recently turned on, the gateway **110** may send a warning message for display on the television **200** instructing the user to plug the television into the AC output port **144** of the gateway **110**. As another example, if the power cord of the television **200** is properly plugged into the AC output port **144** of the gateway **110**, but there is no signal at the CEC pin on the HDMI OUT port **133**, this may indicate that the HDMI connection between the television **200** and the gateway **110** has become disconnected, and a warning message can be delivered to the user to check the HDMI connection (e.g., a message delivered via the LCD display **152** or microphone **154** of the gateway).

Graphical User Interface

The main user interface of the gateway is user-friendly, attractive, and generally makes use of all media sources easy and convenient. This encourages panelists to consume media content via the gateway, thus allowing the gateway **110** to perform the measurement functions. There are at least two options for the gateway's main user interface. FIG. **24** shows a first option for the gateway main user interface wherein the currently selected media source (e.g., TV, game console, etc.) plays in the background, HDMI sources **210** are provided along an arc on a left side of the display, and OTT sources **161** are provided along an arc on a right side of the display. FIG. **25** shows a second option for the gateway main user interface wherein the currently selected media source plays in the background, HDMI sources **210** are provided on a top row of the display, and OTT sources **161** are provided along lower rows of the display.

Exemplary Technological Improvements

Based on the foregoing description, it will be recognized that the system and method for cross-media measurement described herein provides a technological improvement in the form of improved hardware and software devices for reviewing, analyzing and capturing media content presented on a television and various additional media presentation devices within a household. The system provides specific improvements of the conventional systems and related methods. Examples of these improvements over conventional ACR systems are included below. However, the improvements over conventional systems and method are not limited to the examples provided below.

As discussed previously, ACR technology is based on the use of an audio fingerprinting/matching technology, where binary files are compared to a series of audio/pixel references to determine which channels are being watched. In contrast to ACR technology, the gateway **110** leverages machine learning technologies (e.g., computer vision) to perform channel, content and advertising detection directly from the incoming video source, from its embedded OTA Tuner, and from the network traffic coming in/out connected devices. The gateway does not take a single approach for all media consumption options. Instead, the gateway considers the various methods of viewing media, and takes a multi-layer approach to determine the content presented to panelists. The methodology of the gateway does not need to assume the source of content, but instead bases content analysis on the source. This provides for more accurate content recognition and analysis. Furthermore, the gateway is able to definitively identify the decision-making path of content selection.

In order to comprehensively support an ACR solution, the library used for its implementation must include continuous recording of all available TV signals. Recorded stations and geographically distributed backups must be installed at different locations nationwide. The libraries should further include original content that is available across every available streaming service. Advantageously, the gateway **110** does not rely on a reference library. Instead, the gateway makes use of trained machine learning models in order to detect particular items in the watched signal. This is significant both from an accuracy perspective as well as a comprehensive analysis perspective. The gateway is able to reliably detect and measure content that may not be included in an ACR library.

ACR is completely unable to detect a channel/source provider when an event or program is being transmitted simultaneously in different channels. In contrast, the gateway does not have simulcast detection problems since it does not rely on audio. The gateway explicitly tracks the specific source of the content and ads that are delivered to the television. With this methodology we are also able to measure simulcast events (same content broadcasted at the same time in different channels), which is not possible with the ACR approach. The ability to identify sources allows for accurate reporting across the various television platform and device options which then translates to accurate allocation of measurement for both content and ads.

With ACR, beyond schedule supported content environments (i.e., viewing through the use of additional external devices such as video game consoles, DVD players, OTT sources, etc.) are difficult or impossible to detect. The conventional solution to this is a content matching methodology wherein validation of exposure/source must occur via manual panelist confirmation (e.g., manual button pushing). In contrast, the gateway is configured to detect and measure content from any number of different sources (e.g., video games, cable boxes, Blu-ray players, OTT sources, etc.). Thus, the gateway is configured to determine viewing behavior outside of non-linear environments (AppleTV, Roku, Video Game Console, etc.), inclusive of source, content, and ads. Marketers need validated measurement of these environments in order to shift their ad dollars into them.

In addition to the above, conventional ACR systems are not capable of measuring content presented at secondary devices (e.g., mobile phones, computers, etc.). Accordingly, additional hardware, software and meter components are needed in order to measure secondary devices in the ACR environment. In contrast, the gateway includes a dedicated chipset that allows it to act as wireless access point to capture the traffic going through it. This allow the entire household's media traffic to be analyzed and reported by the gateway. The gateway thus provides a single-source cross-platform solution to audience measurement that is capable of detecting media consumption overlaps across television platforms and secondary devices.

With conventional ACR, the timeliness of reporting is reliant on the ACR match-back process which needs at least 24 hours for the various confirmations needed to make the inferences of measurement. In the event of recording quality issues, reprocessing has to be re-run, and information delivery can be importantly delayed or entirely left out. The gateway **110** delivers content detection as it happens, and the information can be delivered to the cloud essentially in real time.

Conventional ACR and related systems require additional peripheral hardware to perform TV ON/OFF detection. In particular, the use of ACR microphones to detect TV ON/OFF is unreliable as the microphones tend to pick up signals from other sources which skews the output data (e.g.,

the microphone may detect television on when the audio is actually from a radio). In contrast to conventional ACR, the configuration of the gateway **110** allows it to definitively identify TV ON/OFF without reliance on a microphone or any peripheral device. All hardware required for TV ON/OFF detection is included inside the gateway **110**, thus allowing TV ON/OFF detection as a built-in feature. As described above, in various embodiments, an AC Loop circuit detects the power consumed by the television connected to the gateway. Additionally, for those televisions that support the HDMI CEC protocol, the detection of TV ON/OFF state can be done via the HDMI output port of the gateway.

Conventional ACR is dependent on the capture of very high quality audio via microphones external to the television. This is problematic and unreliable for numerous reasons, including the possibility for muted televisions, ambient noise, etc. In contrast, the gateway **110** is configured to perform recognition through video content analysis, and particularly analysis of the video signal itself (e.g., in the case of an OTA television signal) or the selected frames of an input source (e.g., in the case of content provided by a cable box). Video analysis (e.g., video frame analysis) is more accurate and effective than audio detection because video analysis avoid the problems associated with audio capture including probability of interference and lack accurate identification and detection.

ACR supported methodologies utilize consumer-grade off the shelf hardware (e.g., portable tablets) which is not meant for the panel environment (thus resulting in short shelf lives). ACR supported methodologies also cannot support a variable device multimedia entertainment system. A patched together approach of several devices is usually necessary and implemented. In contrast to ACR, the gateway is a self-contained system wherein every component required to support each layer of the measurement solution is soldered to the main board. No delicate parts can be easily broken which results in long shelf lives that support the panel environment. The hardware is specifically designed for the in-home panel environment. It is configured to analyze and detect numerous different methods of media consumption. The gateway allows for a passive panelist experience which results in the most accurate, comprehensive and granular single-source data output.

In addition to the above, the consumer-grade off the shelf hardware components and devices (e.g., portable tablet computers) common to many ACR systems are attractive for panelists to use for tasks outside of panel measurement objectives. These devices are thus subject to abuse and a generally shorter lifespan. These devices must also be repeatedly turned on and off and charged, such that a relatively short lifespan is inherent with the device. In contrast, the minimalist design of the gateway **110** results in an innocuous presence in the household that discourages tampering. This reduces the opportunities for equipment loss due to fraud and allows for consistent presence within the household for audience measurement purposes. The gateway is specifically designed for continuous audience measurement (i.e., 24 hours a day, seven days a week) without the need for the user to take any particular action.

Because ACR technologies implement consumer-grade off-the-shelf hardware devices, user experiences are often forced upon the panelist experience when interacting with these devices that would otherwise not be in the home. In contrast, the gateway provides a friendly user interface that leverages the use of the television as a display to show high impact graphics. The panelist experience and behaviors are consistent with those prior to our installation of the gateway. The ability to communicate on the television screen allows the user interface to remain native to the user's existing media consumption environment.

The aforementioned combination of several components, devices, and consumer-grade off-the-shelf hardware with conventional ACR systems has long-term cost implications. The multiple points of failure results in high equipment churn, replacement, and repair costs. This equipment churn also impacts panelist satisfaction/drop-out, which in-turn results in panelist replacement costs. In contrast, the gateway includes all the necessary hardware in one device, is extremely durable, is built for continuous audience measurement real-world environment, has an innocuous presence, and includes an all-in-one measurement approach. As a result, the gateway **110** not only delivers higher data integrity, but also facilitates unique data outputs that can produce higher return on investment.

Although the various embodiments have been provided herein, it will be appreciated by those of skill in the art that other implementations and adaptations are possible. Furthermore, aspects of the various embodiments described herein may be combined or substituted with aspects from other features to arrive at different embodiments from those described herein. Thus, it will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

What is claimed is:

1. A method of identifying media content presented on a display device in communication with a content gateway, the media content provided by a video signal comprising a series of frames, the method comprising:

determining, at a processor within the gateway, a selected input source providing the video signal, wherein the selected input source is one of a plurality of input sources including at least a first input source and a second input source;

selecting a first set of content identification rules when it is determined that the selected input source is the first input source, wherein the first set of content identification rules define a first trigger event and a first algorithm for analyzing one or more of the frames of the video signal following the first trigger event;

selecting a second set of content identification rules when it is determined that the selected input source is the second input source, wherein the second set of content identification rules define a second trigger event and a second algorithm for analyzing one or more frames of the video signal following the second trigger event, wherein the second set of content identification rules is different from the first set of content identification rules; and

applying the selected first set or second set of content identification rules to the video signal in order to generate content identification data for the media content presented on the display device, wherein applying the selected first set of content identification rules includes waiting for the first trigger event and applying the first algorithm to one or more frames of the video signal following the first trigger event, and wherein applying the selected second set of content identification rules includes waiting for the second trigger event

and applying the second algorithm to one or more frames of the video signal following the second trigger event.

2. The method of claim 1 further comprising, transmitting the generated content identification data to a remote computing device.

3. The method of claim 1 wherein the first trigger event is detection of a content grid within one of the frames of the video signal, and wherein application of the first set of content identification rules includes periodically applying a grid detection algorithm to the frames of the video signal.

4. The method of claim 3 wherein the grid detection algorithm is applied to every frame of the video signal provided by the selected input source.

5. The method of claim 3 wherein the first algorithm is a content extraction algorithm applied to the detected content grid.

6. The method of claim 1 wherein the first input source is a specific model of set-top box, and wherein selection of the first identification rules is based at least in part on the specific model of set-top box.

7. The method of claim 1 wherein the second trigger event is passage of an amount of time since a previous frame capture, and wherein the second algorithm is a logo recognition algorithm.

8. The method of claim 1 wherein the second trigger event is detection of a scene change in the series of frames, and wherein the second algorithm is a brand recognition algorithm.

9. The method of claim 1 wherein the display device includes a screen and a speaker, wherein the first algorithm is a first machine-learned algorithm, and wherein the second algorithm is a second machine-learned algorithm.

10. A non-transitory computer-readable medium for identifying media content provided by a video signal delivered to and presented on a display device, the computer-readable medium having a plurality of instructions stored thereon that, when executed by a processor, cause the processor to:

determine a selected input source providing the video signal, wherein the selected input source is one of a plurality of input sources including at least a first input source and a second input source;

select a first set of content identification rules when it is determined that the selected input source is the first input source, wherein the first set of content identification rules define a first trigger event and a first algorithm for analyzing one or more frames of the video signal following the first trigger event;

select a second set of content identification rules when it is determined that the selected input source is the second input source, wherein the second set of content identification rules define a second trigger event and a second algorithm for analyzing one or more frames of the video signal following the second trigger event, wherein the second set of content identification rules is different from the first set of content identification rules; and

apply the selected first set or second set of content identification rules to the video signal in order to generate content identification data for the media content presented on the display device, wherein application of the selected first set of content identification rules causes the processor to wait for the first trigger event and apply the first algorithm to one or more frames of the video signal following the first trigger event, and wherein application of the selected second set of content identification rules causes the processor to wait for the second trigger event and apply the second algorithm to one or more frames of the video signal following the second trigger event.

11. The non-transitory computer-readable medium of claim 9 wherein the first trigger event is detection of a content grid within one of the frames of the video signal, wherein application of the first set of content identification rules includes periodically applying a grid detection algorithm to the frames of the video signal, and wherein the first algorithm is a content extraction algorithm applied to the detected content grid.

12. The non-transitory computer-readable medium of claim 9 wherein the first input source is a specific model of set-top box, and wherein selection of the first identification rules is based at least in part on the specific model of set-top box.

13. The non-transitory computer-readable medium of claim 9 (i) wherein the second trigger event is one of passage of an amount of time since a previous frame capture or detection of a scene change in the series of frames, and (ii) wherein the second algorithm is a logo recognition algorithm or a brand recognition algorithm.

14. A gateway for identifying media content presented on a display device including a screen and a speaker, the gateway comprising:

a plurality of input ports including at least a first input port and a second input port;

an output port configured to transfer a video signal received at the first input port or the second input port to the display device, wherein the video signal includes a series of frames that provide the media content; and

a processor configured to execute a computer application comprising a plurality of instructions which are configured to, when executed, cause the gateway to:

determine a selected input port providing the video signal;

select a first set of content identification rules when it is determined that the selected input port is the first input port, wherein the first set of content identification rules define a first trigger event and a first algorithm for analyzing one or more frames of the video signal following the first trigger event;

select a second set of content identification rules when it is determined that the selected input port is the second input port, wherein the second set of content identification rules define a second trigger event and a second algorithm for analyzing one or more frames of the video signal following the second trigger event, wherein the second set of content identification rules is different from the first set of content identification rules; and

apply the selected first set or second set of content identification rules to the video signal in order to generate content identification data for the media content presented on the display device, wherein application of the selected first set of content identification rules causes the processor to wait for the first trigger event and apply the first algorithm to one or more frames of the video signal following the first trigger event, and wherein application of the selected second set of content identification rules causes the processor to wait for the second trigger event and apply the second algorithm to one or more frames of the video signal following the second trigger event.

15. The gateway of claim 14 further comprising a housing, wherein the processor, the plurality of input ports, and the output port are all retained within the housing, and

wherein the plurality of input ports and the output port are accessible through the housing.

16. The gateway of claim **15** wherein the first input port and the second input port are both HDMI ports.

17. The gateway of claim **16** wherein the first input port is connected to a set-top box, and wherein the second input port is connected to one of a video game console, a disc player, or an OTT device.

18. The gateway of claim **14** further comprising a storage apparatus and a transceiver, wherein the first set of content identification rules and the second set of content identification rules are retained in the storage apparatus, wherein the transceiver is configured to communicate with a remote server, and wherein at least one of the first algorithm and the second algorithm is stored at the remote server, and wherein application of the first application or the second application causes the processor to capture and transmit one or more frames of the series of frames to the remote server via the transceiver for application of the first algorithm or the second algorithm.

19. The gateway of claim **14** further comprising a router, wherein the processor is further configured to detect additional media content presented at a mobile device via the router.

20. The gateway of claim **15**, wherein the processor is configured to register a panelist for association with media presented on the display device based on a signal strength of the mobile device at the router.

* * * * *

EXHIBIT F

VideoAmp Incorporates HyphaMetrics Panel Data Into Audience Measurement

By Jon Lafayette 13 days ago

In big data world, panels still matter, companies say

VideoAmp said it made a deal that will enable it to incorporate data from HyphaMetrics' cross-screen audience panels into its measurement products.

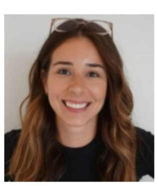
VideoAmp is one of a number of measurement companies jockeying to provide the TV industry with alternatives to Nielsen, which has been under fire because the way it managed its panels led to undercounting viewing during the pandemic.

Also Read: Ad Industry Seeks Alternatives After Nielsen Loses Seal of Approval

ViacomCBS said it would use a currency based on VideoAmp measurement as a currency to plan, transact and measure national media campaigns, a role monopolized by Nielsen.

"At VideoAmp we see panels as an important part of our overall solution set as the industry searches for a new holistic media measurement currency," VideoAmp chief measurability officer Josh Chasin said. "We've been especially impressed with HyphaMetrics' innovative, patented measurement tech stack and we look forward to working together to develop new measurement solutions for buyers and sellers of cross-screen advertising."

VideoAmp said the way it is using HyphaMetrics panel-based data set aligns with the WFA's blueprint for cross-media measurement. The WFA outlines merging census-level big data and panel data to provide a better understanding of consumer media behavior.


Joanna Drews (Image credit: HyphaMetrics)

"Panels play an integral role in providing a definitive understanding of how consumers interact with content and advertising across all of their devices and channels," said Joanna Drews, CEO and co-founder of HyphaMetrics. "We are excited for VideoAmp to incorporate this granular behavioral layer of data, covering all aspects of today's unique viewing environment such as video gaming, secondary device usage and walled gardens."

Drews, a former Comscore executive, started HyphaMetrics, which has developed its own meter to measure every network, program, advertisement, product placement, streaming app and gaming environment on every device in a household. The company expects to have 5,000 homes and 15,000 devices

hooked up to its technology.

In March, HyphaMetrics received a patent for cross-platform measurement.

Also Read: MadHive First To License Panel Data from HyphaMetrics

VideoAmp uses a data set of co-mingled viewership from smart TVs and set-top boxes to measure video across devices. The data is housing on a platform where it can be utilized with tools for planning and optimizing campaigns and valuing media as its being bought and sold.

Also Read: VideoAmp Renews Key Vizio Deal For TV Viewing Information

VideoAmp is a charter member of HyphaMetrics Content Metrics panel trial. The trial, which commenced in July of 2021, will run through the first quarter of 2022 in order to encompass major viewing events like the Super Bowl and Winter Olympics.

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